THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 27. Thursday, January 4th, 1923. No. 333.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.

Foreign and Colonial, 17s. 6d. per annum.

All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be; of

THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI,
LONDON, W.C.2.

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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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Introspective, 1923.

Any digression into the prospects of the foundry industry in 1923 is bound to be problematic, as the data on which one can prognosticate has, as a result of the war, been distorted. Money values are not comparable as the purchasing value of a pound sterling varies from year to year. Foundries are dependent for their business on shipbuilding, engineering, automobile and railway construction, and the metallurgical, textile, chemical, and building trades. This list is by no means complete, but it serves to show that only a general boom in trade can fill the whole of the foundries in Great Britain, but it likewise emphasises that increased business in almost any department of industry is reflected in increased production from the foundries. One factor which should help the foundryman in the near future is the general lowering of railway rates. A question in which foundrymen should interest themselves is the charges on refractories. At the moment no definite decision has been arrived at, and the refractory people require as much support as possible from the foundry industries, as it is they who finally foot the bill. From a comprehensive survey of all the industries, one is inclined to think that foundries on the whole should have better trade than during the past year, providing always, as the lawyers say, that it is free from serious industrial upheaval. Give and take, associated with a general desire to do one's best for the industry at large and the elimination of selfishness on all sides are all that is needed to reduce industrial disputes to a minimum.

Technically, there is much to look forward to. The theoretical papers on foundry practice have now reached a high standard, and this without losing sight of the practical bearing, whilst those emanating from the practical men are better reasoned and show that the underlying principles are being absorbed and utilised. The annual conference of the Institution of British Foundrymen is fixed for June, and the venue will be Manchester. A departure is this year being made by placing the arrangements in the hands of the General Council assisted by a local reception committee instead of leaving the whole arrangements to the local Branch of the Conference centre, which may mean that one man may carry the whole conference on his shoulders, with a personal, instead of a national, organisation being the result. Such a system is fraught with dangers, and the new arrangement is in every way preferable. This year, too, is to see the expansion of an international foundry technical association, which though perhaps not originated by Mr. Oliver Stubbs, has been so much advanced by his visit to the States and his personal work amongst the handful of foreign delegates who were present at the Blackpool Conference. The French Foundrymen's Association have taken up the idea, with the result that a conference is to be held in Paris next September. The Institution is to be represented officially by its Council, a rather formidable body of fifty members. This is to be supplemented by as many members as care to go, and adequate arrangements will be made for their journey and reception.

This, we would have thought, represented a real advance on the technical side of foundry work, but even this may be supplemented by a tour beyond the Parisian region, mainly for the benefit of the American and Canadian visitors. The idea has emanated from the American Committee on International Relations, and should the British decide to join them much mutual benefit should result.

The coming year should find the Royal Charter bearing fruit, by the better recognition of the foundry as a highly-skilled and scientific key industry. It is not generally known that this Charter has cost the Institution some £500, the whole of which has been subscribed privately. The one distressing factor associated with the opening of the New Year is the number of foundrymen who are unemployed, and whilst wishing to avoid politics, we would suggest that by those in employment working harder, positions for their unfortunate confrères will be the sooner forthcoming.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Managers and Foremen by Merit.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—During the last four years or so, I have been constantly struck by the speeches of some of our most eminent foundrymen, which have appeared from time to time in the columns of THE FOUNDRY TRADE JOURNAL, dealing with the laxity of our young men in the foundry world concerning the technical side of the foundry trade.

At the outset my present opinion is that, without influence, "a trier" has very little chance of making good, and has invariably to carry on with "rammer and shovel."

It has been my bitter experience for quite a long period to receive no replies from firms or individuals who have advertised through the usual mediums for managers and foremen.

Quite 80 per cent. of the advertisements which appear specify that the applicant must have previously held some responsible or administrative position. Therefore, I contend that many eligible candidates are deprived that stepping-stone which is evidently essential for getting out of the rut.

Personally, I should welcome a scheme whereby the candidate or applicant who would push on would be subjected to some form of examination or test, both practical and theoretical, in general foundry practice.

Such a scheme, if properly organised and worked by our leading practical foundrymen, would, I think, result in bringing about a state of things beneficial both to masters and men, and placing the right man in the right place. There must be quite a number of young foundrymen like myself who would readily accept the opportunity of qualifying under such a scheme.

A scheme on similar lines was mentioned in your columns a few weeks ago by Mr. Young, in his Presidential Address at Newcastle, who referred to a scheme of tests, as also did Mr. C. A. Otto.

I hope the day will soon be here when we may read in the advertisements: "Only certified foundrymen need apply." A sea-going engineer must have his "ticket"; therefore, why not the foundryman?—Yours, etc., "IN THE RUT."

B.C.I.R.A. Malleable Specifications.

To the Editor of THE FOUNDRY TRADE JOURNAL:

SIR,—I hear from American sources that the B.C.I.R.A. has issued a specification for malleable castings for Admiralty work, but I would ask why it has been necessary to go to America for such information? Surely such a matter is of more interest to us in Great Britain. Even a Member has informed me that he knows nothing about it. I have been in touch with the Secretary of the British Engineering Standards Association, and he, too, is unaware of any such issue. Perhaps you will, in the interest of the British foundry industry, secure and publish this specification, and ascertain the reason for the extraordinary method the B.C.I.R.A. has adopted for presenting the specification to the British public.—Yours, etc.,

"MALLEABLE."

Birmingham, January 1, 1923.

Lathe Tools.—The Lathe Tools Research Committee of the Manchester Association of Engineers have carried out a series of investigations, extending over several years, in connection with the heat treatment, form, durability and power consumption of lathe tools. At the request of the Association, the Department of Scientific and Industrial Research have now published the Report of the Committee. The aims of the Committee were to discover a heat treatment which could be recommended to give consistent results, to evolve a test which could be employed in the workshop as a measure of the durability of a tool, to ascertain the variations in the durability of tools corresponding to changes in the cutting speed, shape, cutting angle, nose radius, etc., and to investigate the component forces acting upon a tool and the power consumed during cutting.

Book Reviews.

"MECHANICAL WORLD" YEAR BOOK, 1923. Published by Messrs. Emmott & Company, Limited, 65, King Street, Manchester. Price 1s. 6d. net.

This well-known reference book has this year incorporated new material specially interesting for foundrymen. Cupola blast, dust and fume-removing, ventilation and pressure losses in duct work, are all subjects of direct interest to the foundry. It is certainly a useful book to have on the office table.

REPORT ON THE ECONOMIC AND FINANCIAL SITUATION OF AUSTRALIA. By S. W. B. McGregor, H.M. Senior Trade Commissioner in Australia. Published by H.M. Stationery Office. Price 2s. 6d. net. This report is divided into eight sections: General Conditions; Government Organisation of Trade; Finance; Commerce and Manufactures; Transport; Public Works; Social Questions; and Legislations. Under the section of Commerce and Manufactures a two-page sub-section is devoted to iron and steel. It is interesting to note that the Commissioner is of opinion that the weak spot in Britain's trade with Australia is in engineering and allied material.

"BUSINESS PROSPECTS" YEAR BOOK, 1923. Edited by D. Willson Lloyd, M.A., and A. P. Barnett. Published by the Business Statistics Company, Limited, Baltic House, Cardiff.

This publication is of use to any firm preparing the programme for the year. Practically every section is interesting to some section of the foundry trade. There are twelve chapters dealing successively with coal, shipping, iron and steel, copper, tin, tinplates, spelter, money market, wheat, cotton, rubber, and oil.

It might be questioned as to why rubber and oil are interesting for foundrymen, but a little consideration reveals that there are foundries who specialise in castings for these two trades. Cotton or textiles have a very important bearing on the prosperity of the ironfounding industry. To be of use the book must obviously be bought now.

STRUCTURAL STEELWORK. By William H. Black. —London: Sir Isaac Pitman and Sons, Limited, Parker Street, Kingsway, W.C.2. (Price 2s. 6d. net.)

This little book is one of Pitman's technical primers, and is intended to meet the demand for an introductory treatise on the calculation and design of structural steelwork. The first half is devoted to a practical treatment of basic principles, these being illustrated by numerical examples. The second part gives general data for design, explains the considerations governing selection of materials and type of construction, and illustrates the application of the theory to the design of a complete foundry building. We must confess having opened the book with some diffidence as to what a beginner could learn from such a small treatise on such a complex subject, but were agreeably surprised at the amount of information the author managed to cram into such a small compass.

As the author invites criticism, may we suggest that he should in a future edition explain how the student is to deal with the support of a cantilever. Let us take, for instance, Fig. 14. The reaction on the centre of the lower bearing is figured as 2 tons, and we are told that the support between *a* and *b* is supposed to be crushed. If that be so, the reaction can no longer be at the centre of the whole bearing, but only at the centre of the uncrushed half. Moreover, assuming that the reaction is still at *b*, according to the principle of moments some 8 tons would be required at the very end of the joist to counterbalance the load.

Institution of British Foundrymen's "Proceedings."

Mr. W. G. Hollinworth, the General Secretary of the Institution, informs us that there remain, after distribution to the members and associate members, a few copies of the last-published "Proceedings." These will be sold to the public at the price of 10s. 6d. each. Early application is advisable.

The Effect of Special Elements on Cast-Iron.—II.*

By Oliver Smalley, M.I.Brit.F.

Effect of Mo on Cast-Iron.

Amongst other things the preceding paper† discusses is the possibility of depositing graphite direct from molten cast iron in a nodular form, by the addition of special elements, without affecting the combined carbon content Experiments with Mo were so interesting as to warrant a more detailed investigation. With this end in view, two irons of the following composition were used as basis materials:—

	T.C.	Si.	Mn.	P.	S.
(1)	3.3	2.0	0.7	0.9	0.10 (under)
(2)	3.3	1.25	0.7	0.5	0.10 (under)

melting in an 8-ton Whiting cupola at a temperature of approximately 1,400 deg. C.

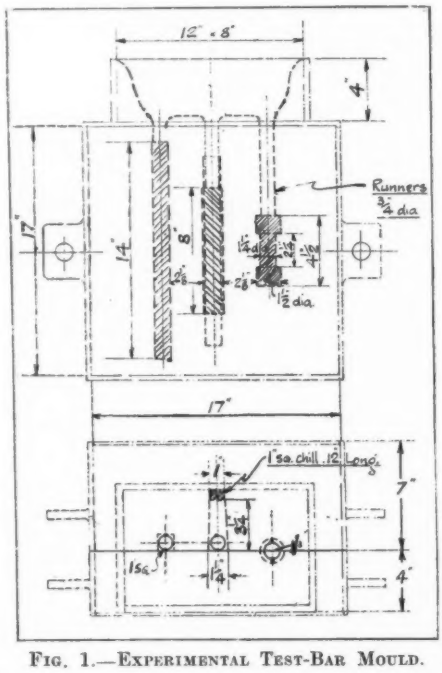

FIG. 1.—EXPERIMENTAL TEST-BAR MOULD.

The Mo was introduced by means of an 8 per cent. Mo, Ferro-Mo stock alloy, which was first melted in a crucible, pouring into the molten iron as the ladle was filling from the cupola. Two casts

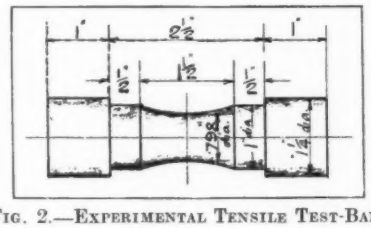

FIG. 2.—EXPERIMENTAL TENSILE TEST-BAR

were made for each test on two consecutive days, in order to obtain true average results.

Physical Tests.

The tests made were fluidity, Keep's shrinkage, tensile, transverse, compression, Brinell hardness and chilling power.

The temperature of the mould used to measure fluidity was accurately controlled at 100 deg. F. Tensile, transverse and chilling test pieces were cast in dry sand in one box, as shown by Fig. 1, controlling the temperature of the mould between 90 deg.-100 deg. F. The tensile test piece was machined to the form indicated by Fig. 2. Transverse bars were broken unmachined on 12 in. centres, and compression test pieces, 1 in. long × 0.798 in. dia., were machined 2 in. from each end of the broken transverse bar. Drillings for chemical analysis were taken from the middle of one half of the broken transverse bar, and tested in duplicate. The chill test piece was sectioned through the middle, one half being used for etching and microscopical examination, and the other for Brinell hardness tests. In preparing the half for the latter, only the black skin was removed from the chill face.

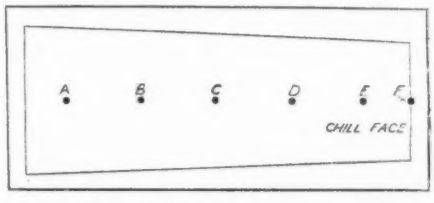

FIG. 3.—BRINELL HARDNESS THROUGH SECTION OF CHILL TEST PIECE.

In Cylinder Metal free from molybdenum, A=207; B=197; C=192; D=217; E=223; F=477. For Cylinder Metal containing 1½ per cent. Mo, A=269; B=248; C=248; D=285; E=285; F=445. For Common Grey Iron, free from Mo, A=229; B=217; C=207; D=229; E=229; F=262. For the same iron, with 1½ per cent. Mo added, A=223; B=207; C=207; D=223; E=223; F=293.

The mechanical test results of the first series of experiments are detailed in Tables I. and II. In Table I., representing ordinary grey iron, 0.10 per cent. Mo is shown to reduce the tensile strength, compression and chilling power, to exert little or no effect on the Brinell hardness, and to increase slightly the transverse strength and the deflection.

Increasing the quantity to 0.25 per cent., the effect is to reduce slightly the chilling power, and increase the transverse strength and deflection

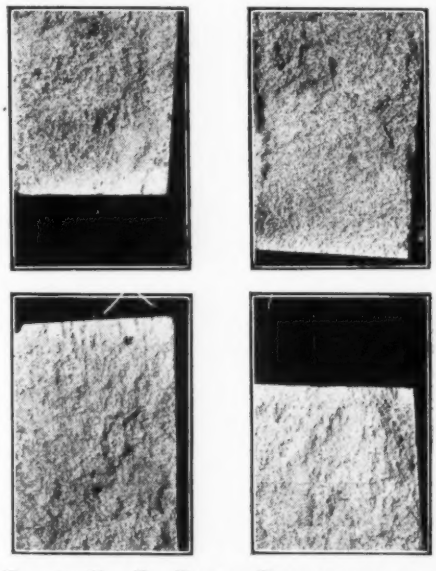

FIG. 4.—THE TOP PAIR OF PHOTOGRAPHS SHOW CYLINDER METAL AND COMMON IRONS WITH 1½ PER CENT. MO ADDED. THE BOTTOM PAIR ARE THE SAME IRONS FREE FROM MO ADDITIONS.

without materially affecting the tensile and compression strength or hardness.

In the presence of 0.50 per cent. Mo apart from the chilling power which is slightly reduced, an all round improvement is effected, which is particularly marked in the compressive and transverse strength.

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* A Paper read before the Sheffield Branch of the Institution of British Foundrymen.

† See "F.T.J." December 21, 1922.

High P. Cylinder Iron.

The effect of small quantities of Mo is more marked on cylinder iron, 0.12 per cent., improving the mechanical properties but reducing the chilling power. The addition of 0.24 per cent. Mo further improves the tensile strength, without materially affecting the hardness, compressive and transverse strengths, although the last two named show a tendency to fall.

the value of Mo in cupola melted irons, where special physical properties are desired in conjunction with the other useful attributes of ordinary grey iron.

In view of the promising nature of these results as a whole, it was decided to conduct a more precise investigation, controlling the T.C. content and melting conditions more accurately, and introducing somewhat larger quantities of Mo. For

TABLE I.

Cast No.	CC.	GrC	Si	Mn	P	S	Mo	Tensile tons per sq. in.	Brinell hardness No.	Compression tons per sq. in.	Transverse. Lbs. per sq. in.	Transverse. Deflect. in ins.	Fracture.	Depth of chill.
1	0.41	2.87	1.94	0.62	0.93	0.076	Nil.	12.2	207	49.5	2,812	0.12	Close grain.	0.09"
2	0.37	3.10	2.03	0.64	0.92	0.070	0.15	10.7	201	43.4	3,010	0.12	Not so close as No. 1.	Nil.
3	0.46	3.01	2.05	0.62	0.90	0.067	0.26	11.9	201	48.1	3,240	0.13	As No. 2.	0.03"
4	0.43	2.81	1.92	0.75	0.89	0.047	0.52	13.2	229	57.2	3,940	0.15	Rather closer than No. 1 with a silky tinge.	0.06"

TABLE II.

Cast No.	CC.	GrC	Si	Mn	P	S	Mo	Tensile tons per sq. in.	Brinell hardness No.	Compression tons per sq. in.	Transverse. Lbs. per sq. in.	Transverse. Deflect. in ins.	Depth of chill.
8	0.87	2.55	1.10	0.85	0.51	0.114	Nil	14.0	217	59.0	3,940	0.12	0.17"
9	0.89	2.41	1.24	0.69	0.51	0.115	0.12	15.8	229	62.2	3,970	0.13	0.02"
10	0.91	2.39	1.26	0.66	0.52	0.096	0.24	17.8	229	57.1	3,950	0.13	0.031"

Fluidity and Shrinkage.

Throughout the conduction of these experiments, neither the fluidity nor total shrinkage of ordinary or cylinder irons was in any way affected by the Mo additions.

Chemical Analysis and Microscopical Examination.

Although carried out with the greatest care, no general conclusions could be drawn concerning the effect of Mo on the combined carbon content. From the examination of the numerous casts made, small quantities of Mo appear to behave somewhat erratically, but the general tendency is to reduce rather than increase the amount of carbide. This is confirmed by microscopical examination, *e.g.*, Casts 2 and 3, Table I., containing 0.10 per cent. and 0.25 per cent. Mo respectively, exhibit a

this purpose, two consignments of run-down iron were prepared, one being a special cylinder iron of exceptionally low T.C. content, the other an ordinary common grey iron containing a T.C. of approximately 3.2 per cent., Si 2 per cent., and P 0.90 per cent.. Melting was performed in a forced-blast crucible furnace, controlling both time and temperature of melting, thus eliminating the variations of chemical composition, which inevitably creep in when melted in the cupola.

Each melt was 50 lbs. The desired quantity of Mo was introduced by means of an 8 per cent. Mo ferro-molybdenum stock alloy, casting in the same type of mould as was used before. The casting temperature of the cylinder metal was controlled at 1,302 deg. C., and of the ordinary metal at 1,262 deg. C.

TABLE III.

Cast	CC.	GrC	Si	Mn	P	S	Mo	Tensile tons per sq. in.	Brinell hardness No.	Compression tons per sq. in.	Transverse. Lbs. per sq. in.	Transverse. Deflect. in ins.	Fracture.	Depth of chill.
11	0.61	2.24	1.54	0.55	0.54	0.114	Nil.	18.4	223	61.2	2,972	0.12	Fine close grain.	0.16"
12	0.60	2.17	1.68	0.66	0.62	0.082	1.55	23.0	269	75.0	3,233	0.10	As 11, but has a silky appearance.	0.15"

TABLE IV.

Cast No.	CC.	GrC	Si	Mn	P	S	Mo	Tensile tons per sq. in.	Brinell hardness No.	Compression tons per sq. in.	Transverse. Lbs. per sq. in.	Transverse. Deflect. in ins.	Fracture	Depth of chill.
13	0.43	2.87	1.98	0.61	0.87	0.083	Nil.	15.2	221	58.2	2,762	0.12	Close grain.	0.06"
14	0.38	2.88	2.00	0.60	0.87	0.076	1.49	16.3	223	63.9	3,122	0.116	As above, but inclined to be silky and lighter in colour.	0.04"

coarser graphite flake than irons altogether free from Mo, and this was particularly marked in Cast No. 2. In the presence of 0.50 per cent. Mo the graphite appears to behave in a more regular manner, and the flakes are somewhat reduced in dimension.

Cylinder metal, containing 1.25 per cent. Si and 3.3 per cent. TC, was not subjected to the anomalous behaviour of small quantities of Mo on the deposition of the graphite, although this peculiarity appeared in casts containing both 1.5 per cent. and 1.70 per cent. of Si. This series of experiments offers no evidence that small quantities of Mo affect the combined carbon content of the harder irons. They do emphasise, however,

The average results of this series are given in Table III. and IV. It will be seen that 1½ per cent. Mo increases the tensile strength of cylinder iron 25 per cent., the compressive strength 22 per cent., and the transverse strength 9 per cent. without materially affecting any of the other useful properties.

The average test results from an extensive investigation of this alloy surpass anything the author has ever obtained from cast iron or semi-steel in almost every respect, particularly in closeness of grain. On common grey iron, crucible melted, the same quantity of Mo exerts a similar all-round improvement, giving the cleanness and fluid life of a soft iron with the properties of a cylinder iron.

Chilling Power.

The effect of Mo on the chilling properties and hardness is shown by Fig. 3, representing the actual Brinell hardness Nos. at the positions shown throughout the section. All Brinell tests were made with a 10 m.m. ball under a load of 3,000 kilos. for 45 secs. Cast Nos. 11 and 12 suggest Mo actually to decrease the chilling effect despite its beneficial influence in other directions, although there is an increase in the hardness of the iron itself, and an improvement in the uniformity of

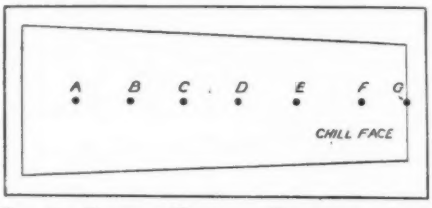


FIG. 5.—BRINELL HARDNESS THROUGH A 6 PER CENT. CAST IRON.

A=375; B=375; C=388; D=401;
E=415; F=555; G=601 to 627.

hardness and solidity throughout. Cast Nos. 13 and 14 represent an ordinary grey iron, showing 1½ per cent. of Mo to have little effect on either the chilling power or Brinell hardness. Fig. 4 shows the fractures of chill cast test pieces.

Chemical Composition and Micro-Structure.

The limited nature of these investigations makes it impossible to express definite conclusions. It is quite reasonable to assert, however, that Mo is a most effective scavenger and desulphuriser, and although it generally tends to reduce the actual carbide content, this might easily be accounted for by the lowered S content. This probably explains some of the improved toughness. There is no doubt, however, that Mo refines the grain by reducing the dimension of the graphite flakes and toughens the ferrite matrix; factors mainly responsible for the improved strength. In the case of high Mo series, this is clearly shown in the fractures, these being a particularly fine grey with a

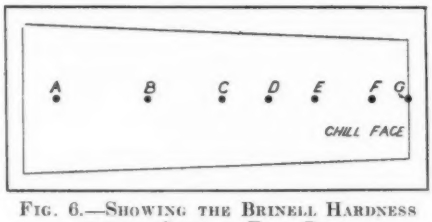


FIG. 6.—SHOWING THE BRINELL HARDNESS THROUGH CHILLED TEST PIECES.

For Common Grey Iron: A=207; B=187; C=192; D=201; E=212; F=217; G=281. Common Grey Iron, with 0.11 per cent. Cr. added, gave A=192; B=197; C=207; D=217; E=235; F=235; G=453. Common Grey Iron, with 0.78 per cent. Cr., gave A=229; B=205; C=217; D=227; E=241; F=293; G=453. Plain Cylinder Metal gave A=207; B=192; C=201; D=212; E=217; F=229; G=444. Cylinder Metal, with 0.15 per cent. Cr. added, gave A=207; B=192; C=197; D=212; E=217; F=241; G=461. Cylinder Metal, with 0.75 per cent. Cr., added, gave A=252; B=207; C=248; D=297; E=341; F=388; G=550.

silky appearance. In some respects, they bear a close resemblance to a Mo steel. This comparison is advantageously emphasised in the chill section of an Mo iron containing 6 per cent. Mo of the following composition:—Mo, 6.33 per cent.; C.C., 1.24 per cent.; Gr, 1.96 per cent.; Si, 1.84 per cent.; Mn, 0.60 per cent.; P, 0.80 per cent.; and S, 0.05 per cent. The Brinell hardness through the section is shown by Fig. 5. The most arresting feature of this iron, however, is the micro-structure, Fig. 7. Although containing 1.96 per cent. of graphite, none of it exists in flake form, but is distributed throughout in well-defined nodules.

The foregoing investigation has decidedly established the value of Mo as a strengthener, toughener and grain refiner. The introduction of quantities under 0.50 per cent. does not affect the machining properties, but exceeding this, the iron becomes increasingly difficult to cut, although exerting no effect on the tenacity hardness.

Abrasive tests have furnished most promising evidence of the particular value of Mo in the manufacture of castings such as stone-crusher jaws, grinding plates, and cylinder and pump liners, where wear is of primary importance, and present great possibilities to the car wheel and chill roll maker.

EFFECT OF Cr ON CAST IRON.

The study of Cr cast iron has revealed a field of investigation pregnant with possibilities. The two primary objects of this particular research were (1) To explore briefly the general characteristics of chromium cast irons, and (2) to determine the commercial value in the manufacture of Diesel, locomotive, automobile and marine-engine cylinder castings.

Dr. Hatfield, in his valued contribution to the subject, states that the action of Cr is probably two-fold:—(1) By crystallising with the carbide it renders the C.C. (combined carbon) more stable. The addition of Cr, therefore, tends to harden cast iron and increase the chill. The Gr also separates with increasing difficulty, as the percentage of the element under discussion increases. (2)

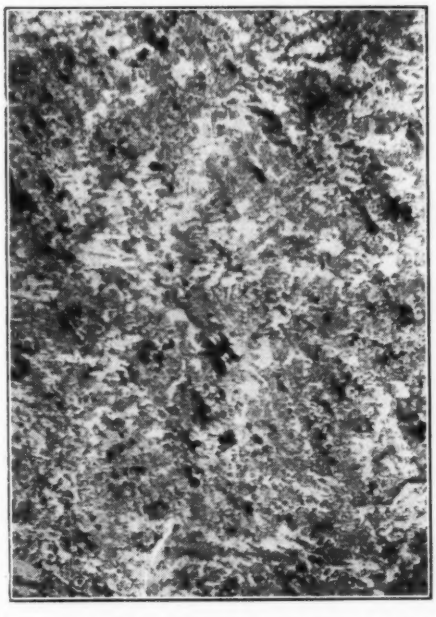


FIG. 7.—MICRO-PHOTO OF 6 PER CENT. Mo C.I. MAGNIFIED 100 TIMES. IT IS FROM A 1½-IN. SECTION CAST IN OPEN GREEN SAND.

It is most probable that Cr remaining in the ferrite definitely modifies the characteristics of that constituent, and since after all ferrite constitutes the matrix of cast iron this phase is worth considering.

Two irons of the following chemical composition, run down into pigs from the cupola, were used for these experiment:—

Type of iron.	No. of iron.	T.C.	Si.	Mn.	P.	S.
		%	%	%	%	%
Ordinary grey iron	1	3.1	2.0	0.7	0.9	0.10
Cylinder iron	2	3.35	1.30	0.70	0.50	0.10

These were re-melted in 50-lb charges in a crucible furnace, with the required amount of Cr introduced by means of a 65 per cent. Cr ferro-chrome, controlling both time and temperature of melting.

The method of moulding the test-pieces was that adopted in the Mo experiments, controlling both the temperature of the mould and temperature of pouring in the same way. Test results obtained are detailed in Tables V. and VI.

Common Grey Iron.

The effect of 0.11 per cent. Cr, test Cr2, Table V., is to increase slightly the tensile strength, transverse strength and Brinell hardness. With 0.78 per cent. Cr, the tensile strength falls to that obtained from an ordinary grey iron, the transverse strength is little affected, but the Brinell hardness is raised 40 points.

The cause of this is apparent from the fractures of the chill test-pieces, iron Cr3 being clearly mottled to a depth of 0.61, whilst in iron Cr2, although the chilling power has only been slightly increased, it has appreciably refined the texture. The varying hardness through the chill test-pieces is delineated by Fig. 6. The diagram is self-explanatory of the hardening propensities of Cr, and fully confirms Dr. Hatfield's prognostications.

The value of Cr in cylinder metal is shown to be very limited in the manufacture of small castings. Alloy V.C.2, containing 0.15 per cent. Cr, certainly gives an 8 per cent. increase of tensile strength, 7 per cent. increase of transverse strength, and 18 points in Brinell hardness, but these advantages alone scarcely justify its use. Superior and more easily controlled tests are readily procurable from semi-steel or a good-quality cold-blast iron. In the presence of 0.75 per cent. Cr, the iron is mottled throughout, the transverse test showing a combined carbon content of 1.14 per cent., whilst the tensile test is little better than sample V.C.1. The transverse strength, however, is increased 19 per cent. and the Brinell hardness raised 120 points.

The marked chilling effect of small quantities of Cr is shown by Fig. 6. These clearly demonstrate the relative chilling power of ordinary Cr cast irons.

In the case of ordinary cylinder iron, the depth of chill is increased from 0.068 to 0.90 by the introduction of 0.78 per cent. Cr, a feature of great importance in the manufacture of chill-rolls, car wheels, cylinder castings, gear wheels, and castings of any dimensions where toughness and hard-wearing surfaces are of primary and vital importance. Its possibilities in overcoming grain weakness, due to mass effect, is also quite apparent. By increasing the solubility of C, Cr should confer greater fluid life to cast iron, and suggests a means of overcoming the objectionable liquidation effects of the phosphide in castings of varying sections—a defect all too common when the phosphorus content exceeds 0.30 per cent.—and of effecting an all-round improvement of the physical properties at the same time.

In conclusion, the author desires to express his thanks to the directors of Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., for their kind permission to publish this paper.

TABLE V.

Mark.	CC.	Gr	Si	Mn	P	S	Cr	Tensile.	Fracture.	Transverse Lbs.	Deflection.	Brinell hardness No.	Depth of chill.
Cr.S.	0.56	2.57	2.04	0.72	0.86	0.10	—	14.2	Close grey. ..	2,610	0.10	221	0.05" sharp.
Cr. 2	0.63	2.35	1.94	0.75	0.73	0.099	0.11	15.8	Fine close, grey.	2,810	0.10	241	0.11" sharp.
Cr. 3	0.92	2.51	1.84	0.70	0.80	0.106	0.78	14.0	Slightly mottled	2,796	0.10	261	0.12" sharp. Mottled to 0.61".

TABLE VI.

Mark.	CC.	Gr	Si	Mn	P	S	Cr	Tensile.	Fracture.	Transverse. Lbs.	Deflection.	Brinell hardness No.	Depth of chill.
V.C. 1	0.59	2.76	1.38	0.57	0.50	0.118	—	14.7	Close grey. ..	2,746	0.10	221	0.068" sharp.
V.C. 2	0.56	2.81	1.52	0.50	0.40	0.106	0.15	15.9	Very fine, close grey.	2,955	0.11	239	0.18" sharp. Mottled to 0.40" depth.
V.C. 3	1.14	2.16	1.34	0.55	0.35	0.109	0.75	15.4	Mottled. ..	3 282	0.09	341	0.90" sharp. Mottled throughout.

High-Speed Steels.

The most recent views on the theory of the composition and properties of high-speed test steels were summarised in a Paper read recently at a meeting of the Birmingham Metallurgical Society by MR. J. REGINALD PAGE (Birmingham Small Arms Company's laboratory), who has himself conducted some researches into the subject.

The subject, Mr. Page remarked, was very complex and large, owing to the variety of combinations of the different constituents of these alloys. The history of high-speed steels really commenced in 1860, when Mushet introduced his self-hardening tungsten steel. Later, chromium was added, but the characteristic of these earlier alloys was the comparatively high carbon content. These developments culminated in the exhibition of tools cutting while red hot by Taylor and White at the Paris Exhibition in 1900. Further developments had been made during later years by the introduction of vanadium, molybdenum and cobalt. Also the carbon content has been reduced, so that modern high-speed steels had the following range of composition:—Carbon, 0.45-0.85; silicon, trace-0.2; manganese, 0.1-0.5; tungsten, 8.0-18.0; chromium, 2.5-6.5; molybdenum, nil-2.0; vanadium, nil-1.5; cobalt, nil-5.0 per cent.

The effect of the addition of the various constituents was briefly explained. Owing to the vastness of the subject, the author dealt in detail with only one type, the series having the following approximate compositions:—Carbon, 0.55-0.65; silicon, less than 0.2; manganese, 0.45-0.65; tungsten, 13.5-14.0; chromium, 3.5-4.0; vanadium, 0.35-0.5 per cent.

Dealing with the effect of tempering, the author showed that properly-hardened high-speed steels resisted tempering better than improperly hardened high-speed steels, even though the hardness originally might have been the same. Curves of hardness after tempering were given, it being shown that on tempering an improperly hardened high-speed steel, although possessing a high initial hardness, the steel lost its hardness gradually from 200 deg. C. to 750 deg. C. A properly-hardened high-speed steel became appreciably softer when tempered in the range 400-500 deg. C., but a rise in hardness was noted at 600 deg. C., this phenomenon being termed "secondary hardening."

On the subject of heat treatment, the two methods of hardening were described, namely, (1) heating in a dry furnace, such as a gas-fired or oil-fired furnace, etc.; and (2) heating in a bath of fused salts. The various advantages and disadvantages of each were discussed. Air-hardening in an air blast or oil-quenching could be resorted to, the method depending upon the work being dealt with. Tempering could be effected in an oil bath up to 300 deg. C. For the range up to 550 deg. C. a mixture of fused sodium and potassium nitrate might be used, whilst for the higher range in the neighbourhood of 600 deg. C. a ternary mixture of fused chlorides of sodium, potassium and calcium was useful.

The testing of high-speed steel, continued the author, was a matter of importance for further research. There was very great need for some simpler test by means of which tools could be checked in order to be sure that the heat treatment and cutting properties were satisfactory. The usual method of testing necessitated the scraping of the tool, and consequently a batch had to be passed through on one test taken from the batch. File and Brinell tests, although useful, were very often misleading when testing the cutting efficiency of high-speed steel tools. There did not seem to be a very clear relationship between file tests and Brinell tests on hard high-speed steel, as had been pointed out by Ogilvie.

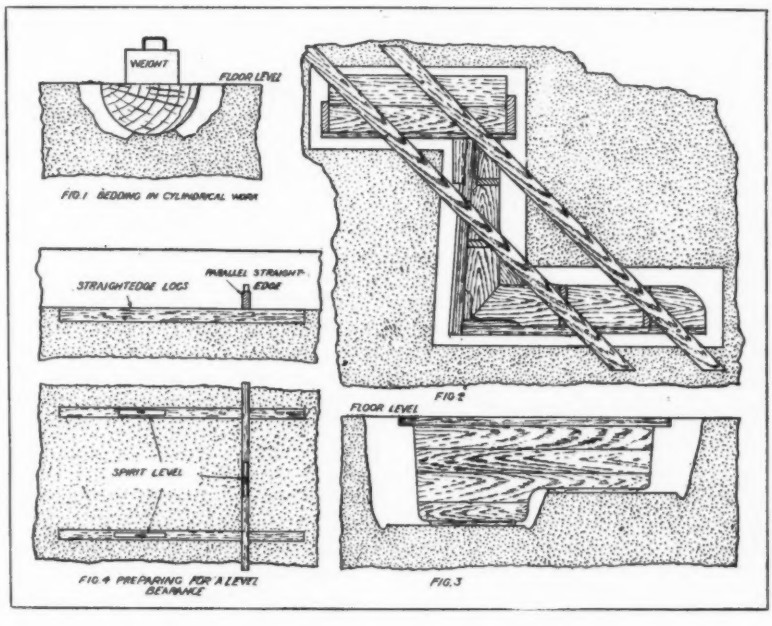
SIR JOSIAH STAMP has been elected to the board of Nobel Industries, Limited, in succession to the late Mr. K. L. C. Prescott.

An Apprenticeship Course in Foundry Practice.—XXIV.

By Ben Shaw and James Edgar.

THE PREPARATION OF DRY SAND MOULDS.

The principles underlying the practice of making dry-sand moulds do not materially differ from those involved in the preparation of moulds in green-sand. There is the same need for venting, although not to the same extent as in green-sand work, when additional provision must be made for the rapid escape of steam generated. In moulds that are dried no such provision is necessary, but there remains the increased volume of air contained in the moulds, due to the rapid rise in temperature directly any metal is poured into it, and gases generated by the influence of the high temperature of the metal on the mould. Then with regard to ramming, although there is the same need for the moulds to have a regular density of sand as in green-sand moulding, there is not the same need for that lightness of touch so desirable to the green-sand moulder. Moulds to be dried can be rammed harder with safety than green-sand moulds, because when the moisture is evaporated the sand is left more porous than a sand of similar fineness containing moisture. This harder ramming is particularly necessary about the bottom of a deep mould, in order that it will retain the shape given to it before the increased pressure of the molten metal. The methods by which moulds which are to be dried are prepared follow on somewhat similar lines to those in green sand, and are covered by the processes known as turning or rolling over and bedding in. Proportionately there are more dried moulds prepared by means of the bedding-in process than in green-sand work, because the general run of work cast in such moulds is larger and is not profitably prepared by the turn-over process without special box-equipment. When the number of castings required from any one pattern is considerable, or when full box-equipment that would be needed in order that the turn-over process could be employed, could be used in other work, with or without slight modifications, it might be worth while considering the making of suitable boxes, but it depends very largely on the number of similar castings likely to be wanted, and anything out of the general run of work, for which boxes are not available, is generally made on the foundry floor, or in some cases sunk in the floor and the turn-over process cannot be employed. The making of special boxes besides being a large expense, especially if the work to be made is of considerable size; they take up a lot of valuable space, and after they have been used for their specific purpose, frequently become more or less "white elephants." They are usually stacked for future use. There are not many foundries that do not possess a large variety of such special boxes tucked away in every conceivable place, and rarely are they disturbed once they have been safely put out of the way. Moulding boxes should be so designed that their usefulness is not narrowed down to one or two jobs unless a large number of such jobs make their construction worth while. It is mainly because of the high initial cost of making special box equipment that the foundry floor is used to a considerable extent for making the drags for medium- and large-sized work, and although this practice is prevalent in green-sand works, it is employed to a greater extent in the making of moulds to be dried because the percentage of medium- and large-sized castings so made is greater.



Turn-Over Methods.

While preference is usually given to the bedding-in process, particularly in jobbing foundries, this does not mean that there is no place for the turn-over method of preparing moulds. Within limits, which exclude the larger work, it is profitable to make use of the turn-over method, providing the equipment is available. There is, of course, greater call upon the crane facilities, but there are important advantages that counterbalance this, as, for instance, the greater convenience in the preparation of the mould by such a method. The use of boxes which the method necessitates facilitates the drying of the moulds as they can be transported to drying ovens readily, and when they are assembled and prepared to receive the metal, the moulds can be moved into the most suitable positions for casting. Thus a mould made in boxes can be prepared horizontally and cast vertically if desired, a practice which is quite common in brass foundries and is not by any means uncommon in steel and iron foundries.

Preparing moulds to be dried by the turn-over process does not differ from that which has already been referred to in a previous article in this

series under the heading of " Green-Sand Moulding," although a ramming board is less frequently employed. A level bed is usually prepared on the foundry floor, and the pattern or pattern section laid upon it in an inverted position. The drag box part is located about the pattern and on the prepared bed, additional bars or soldiers being introduced when necessary before any sand is rammed over the pattern. It is necessary to prevent patterns from delivering themselves when the drag is lifted for turning over, although in many cases when the depth is considerable there is little likelihood of it occurring, but it is best to be on the safe side.

The level bed of sand on the foundry floor is often an advantage when the joint surface of the pattern is not level; projecting parts that are required to be carried in the cope can easily be bedded in the sand, so that the impression taken of the level bed forms the joint of the mould. Slight modifications may, of course, be necessary in some cases after the drag has been turned over and before the cope part is located.

Bedding-In.

The expression " bedding-in " is usually applied to that method of making a mould in which the bottom section or the pattern as a whole is bedded into a previously prepared position in the sand floor. It may, however, be applied more widely to the preparation of all moulds, for which a pattern is used, when the mould is formed in the position in which it is to be cast and without the turning over of the drag. The process consists in the making of a hole, usually in the sand floor, larger than the pattern to be bedded-in, milled facing-sand is thrown over the bottom, and into this the pattern is forced until its surface coincides with the height at which it is desired to make a joint for the cope. With this method there is the possibility of the sand forming the bottom impression of the pattern being hard in some places, while in others it will be comparatively soft. It is therefore necessary to bed in the pattern by easy stages in order to obtain more regularity in the density of sand. This is done by removing the pattern loosening and removing sand from hard places and adding sand to those which appear too soft and again bedding the pattern into the position it previously occupied. This process is repeated until the bottom impression is apparently of similar density and the pattern has been set in the required position relative to the floor level, to the joint surface of a box part, or to the surface of a case or box bedded into the ground, whichever is being used for the drag. During the process of bedding-in patterns are hammered down, and they should be protected from the direct blows of the hammer by interposing a block of wood.

When the pattern has been satisfactorily bedded-in, facing sand, backed with floor sand, is rammed against the sides, and under projecting parts, difficult of access for the rammer, the sand should be compressed with the fingers. During the process of ramming the screws, or skewers, which may be used for holding the projecting parts, which must be loose, are removed. It is, of course, necessary to exercise care with the ramming of the sand when parts are loosened from the sides of patterns, otherwise they are likely to be displaced. When the work is completely rammed-up, the joint can be formed preparatory to making the cope. This form of bedding-in is usually applied to the smaller class of work, whether in green- or dry-sand, for which boxes are not available for adopting the turnover method. There are two main alternatives to this form of bedding-in. Instead of the pattern section being hammered into the sand and removed, and the process continued until the sand forming the bottom of the impression is of regular density, a level surface or bed may be prepared on the foundry floor and a hole formed to accommodate the pattern and section. Facing sand is introduced to support the section so that its joint-surface coincides with the prepared surface of the floor. Weights are used to hold the pattern in position, while sand is rammed about it. When the pattern section is fairly strong, the prepared surface on the foundry floor is unnecessary, as the sand joint can be levelled off flush with the surface of the pattern. This method of bedding-in is only possible when there is sufficient room for ramming the sand after the pattern has been set, and is the method adopted for cylindrical work when moulded horizontally, an example of which is illustrated in Fig. 1. Preparing a level surface on the foundry floor is more common in steel foundries dealing with large castings, the patterns for which are comparatively frail and represent more nearly the shape of the required casting. In order to retain the true shape and prevent twist, battens may be secured to the joint surface of the pattern and projecting at the sides so that they will rest on the prepared floor surface while the job is being rammed, Fig. 2. Weights are still necessary, of course, to prevent the job from being rammed out of shape. If it is desirable to cast work inclined to the horizontal in order to obtain a sounder casting—a practice frequently adopted when vertical casting is not possible—then the prepared surface on the foundry floor must be at the required angle. This is usually referred to as casting on a bank. The other form of bedding-in a pattern is of special value when the pattern is large and is comparatively flat on that surface which is to be cast down. In such cases a level bed is prepared at the bottom of a pit or case set in the foundry floor, and at a distance from the floor surface, so that when the pattern is located the top will be in a suitable position for making the cope. In this way the sand forming the bed becomes the bottom-part of the mould, and apart from the greater ease in locating the pattern in the desired position, it possesses the advantage of being rammed readily to the required density before the pattern is introduced. When the bottom surface of the pattern is on the whole flat, but carries subsidiary projecting parts, the pattern is located on the bed, so that an impression will be made by these projecting parts, and, on the pattern being removed, they are bedded-in separately. When these have been set into the bed they should be withdrawn and attached to the main pattern section, which is then located so that the impression in the bed will be filled. Some moulders bed-in the small parts and endeavour to locate the main pattern section over them, but errors are more likely to occur. When the bottom of the pattern is not continuous and in the same horizontal plane, but consists of surfaces parallel to each other, a special bearance is required, upon which the different surfaces of the pattern will rest. Such an instance is illustrated in Fig. 3. It is very necessary, when this method is used and after the pattern has been set, to ram the sand thoroughly against the pattern and between the two bearances before any attempt is made to ram sand about the sides.

The Preparation of Bearances.

Whatever form of bed is required, it is important that it should conform to the shape of the pattern, or, when the pattern is frail or badly constructed, and has become twisted to the shape the casting is required to have. An improperly or carelessly-prepared bearance generally results in a distorted casting, because, owing to weights applied, patterns frequently follow the shape of the bed. Substantial straightedged logs should be used and when bedded into the sand should be carefully tested with a spirit-level, both in the direction of their length and between each log. For the latter purpose, a parallel straightedge is necessary, so that when it rests upon each log, as in Fig. 4, the spirit-level can be used on the top edge. When the work requires two bearances in different planes, the bottom bearance should be made first and the logs set at the required distance above it for the second bearance. Bearances should always be carefully checked after they have been made and before the logs are withdrawn, in case the logs have been shifted while ramming.

THE MODEL ENGINEER EXHIBITION opens for the sixth time at the Royal Horticultural Hall, Westminster, on Friday, Jan. 5, for one week.

The Foundry Cupola.*

By Robert Buchanan (Birmingham), Past President of the Institution of British Foundrymen.

Historical.

Before considering the present-day foundry cupola as we know it, a short study of its history may prove of interest.

When the difficulty of making wrought iron and steel is considered, it is a singular fact that these metals were in use for many centuries before cast iron was known, or, at least, was of sufficient importance as to be used commercially, or to be commented upon by observers of the period. Steel and wrought iron were known to the Chinese more than 2,000 years ago. No doubt steel was also used by the ancient Egyptians when hewing out the great stones for building the Pyramids and other structures. The remaining portions of wrought iron or steel hinges were found on the door of a tomb in the Pyramids.

In the author's opinion it is a myth that the ancient Egyptians could harden copper tools sufficiently to dress granite blocks.

There is now in the quarry at Baalbec, in Syria, a granite block 70 ft. long by 14 ft. square. It was undoubtedly quarried out with steel tools, which have perished by the efflux of time and climate.

Coming to a historical period, when it was thought of sufficient importance to record these things, it is found that wrought iron and steel were made principally in two types of furnaces. One was called the Catalan furnace. It was much used in Spain; hence its name. It was a very crude type of furnace. It was blown by what was known as a "trompe." This was a hollow tree with suitable openings for the incoming and outgoing air. The air was set in motion by a fall of water down the hollow tree. The water, of course, did not fill the whole interior of the "trompe," but drew down with it sufficient air to keep the furnace going. The "Catalan" was in use in Spain as late as the middle of last century. Charcoal was used in it as fuel, and wrought iron or steel was made in it, according to the percentage of carbon contained in the product.

As knowledge and enterprise advanced in the West, so came increased size of furnaces. Thus there came into existence the "Blauofen" or "Bloomery" furnace. This was used for the production of wrought iron, but by raising the tuyere and by using more charcoal it could be made to produce cast iron. They seldom exceeded 15 ft. high by 6 ft. at their widest diameter. Charcoal was the fuel, and bellows were used for the blast. The "Bloomery" furnace, which sometimes produced wrought iron, and, by the raising of the tuyere and using more charcoal, produced cast iron, was the true progenitor of the blast furnace and foundry cupola.

The first time that cast iron came into prominence in England was in 1543, in the reign of Henry VIII., when Ralph Hogge, at Bucksteed, in Sussex, made a cast-iron cannon. Probably this was cast directly from the blast furnace.

Hogge had as an assistant Peter Baude, a Frenchman, whom he had brought from France to show him improved methods of founding. This shows that the founding of cast iron had been in considerable use on the Continent of Europe—at least, so far as France is concerned. Baude evidently began business on his own account as a maker of cast-iron cannon, for we are told that John Johnson, a "covenanted servant" of Baude's, exceeded his master "in his art of casting ordnance, making them cleaner and to better perfection." Thomas Johnson, son of John Johnson, and mentioned as being a "special workman" in and before the year 1595, cast for the Earl of Cumberland forty-two "great pieces of ordnance," each weighing 6,000 pounds. Fairbairn hazards the opinion that the change from the "blast-bloomery" to the blast furnace took place early in the sixteenth century. The author is of opinion that it is very improbable that the change was so late as that. Were the first blast furnace installed in the year 1501, it is most improbable that the art of casting iron had progressed so rapidly as to admit of the casting of cannon only forty-two years later.

The Sovereigns of England owned two blast furnaces in the Forest of Dean, these being erected about the year 1550, in the reign of Edward VI. By the time Elizabeth was on the throne the English founders had evidently outdistanced their rivals in the excellence of their cannon, as there was a considerable export trade to the Continent in these engines of war.

First Cast Iron Cooking-Pot.

In the year 1709 Abraham Darby, a native of Birmingham, was in charge of a brass foundry in Bristol. For hundreds of years the Dutch had been famous as bell founders, and it was from Holland that Darby obtained his skilled men. Abraham Darby conceived the idea of casting cooking-pots of iron, and set his brass founders to do so, but they failed. Possibly they did not want to succeed. With the assistance of a Welsh boy, John Thomas, Darby himself managed to cast a pot successfully. The pot was cast in a wooden moulding-box: probably these were in regular use for brassfounding at that period. The iron was almost certainly melted in a crucible, with charcoal as fuel, the coking of coal not yet being known. The secret of how to make cast-iron pots was kept by Darby and Thomas and their successors for over one hundred years. Dr. Percy was told by a lady member of the Darby family, living about 100 years ago, that the secret consisted of using fine sand and venting the sand thoroughly for the passage of the gases liberated when the iron was poured. As brassfounders now use a closer and finer sand than do ironfounders, the explanation is probably inadequate. Until coking of coal was accomplished, probably the melting of the iron was the greatest difficulty.

It is worthy of note that betwixt the first recorded instance of a cast-iron cannon being made in England and the first cast-iron cooking-pot there was a period of 166 years.

The Foundry Cupola.

The foundry cupola, considered as a furnace, is unique in simplicity of form. It consists of a vertical cylinder, lined with fire-bricks or other refractory material, having openings, called "tuyeres," by which the blast enters a door through which the coke, iron and limestone are charged, called the "charging door," and a small hole at the bottom by which the molten iron is drawn off, called the "tap hole." There is also a door on the side at bottom, through which entrance is made to fettle the cupola and to make repairs when necessary, and through which the kindling is put in at the beginning, and the débris is drawn out at the end of the cast or melt. This bottom door is made up previous to the blast being put on, so as to be proof against any metal getting through.

The modifications of the short, vertical cylinder, with two blast pipes, which have had any permanence are:—

(1) Heightening the cupola by increasing the distance between hearth and charging door.

(2) Having a blast belt and, connected with the blast belt, double and sometimes triple rows of tuyeres.

(3) Internal modifications of the sections of cupola containing the tuyeres by which the blast of air reaches the centre of the fuel forming the bed.

In the times before lifts or hoists were in general use founders necessarily had to keep their cupolas sufficiently low, so that pig-iron, scrap iron, coke, etc., could be elevated to the charging platform by manual labour. This system obtains in many foundries to-day. These are necessarily compelled to use short cupolas.

The introduction of lifts or hoists made the lengthening of cupolas between hearth and charg-

*Paper read before the Sheffield Foundry Trades Technical Association.

ing door a simple matter, and so the advantages due to such lengthening could be readily obtained. These advantages are principally the utilising of the heat, not directly expended in melting, by heating the descending charges of iron about to be melted, and in keeping the charging door cool.

The increase of distance between hearth and charging door brought into effective use double and triple rows of tuyeres, with the better distribution of blast, more rapid combustion, and quicker melting.

Tuyere Considerations.

Double rows of tuyeres may be used, of course, on cupolas measuring 8 ft. to 10 ft. between hearth and charging door, but in such the waste heat going up the stack or chimney would be excessive.

Double or triple rows of tuyeres must be accompanied by increased height, so that the heated gases may part with the greater portion of their heat before finally going up the stack.

The number of tuyeres varies considerably in different foundries. Cupolas are being blown through one tuyere only, and, on the other hand, in one important works over 30 tuyeres are used on one cupola. In the latter over 80 tons are melted per day with a very low consumption of coke. This economy in coke is no doubt partly due to size of the melt.

Flat, continuous tuyeres have come into considerable use of recent years. These, no doubt, provide a ready passage to the blast, but, if they are very low down towards the hearth, the blast playing on the top of the slag which is floating on the top of the molten iron may, and sometimes

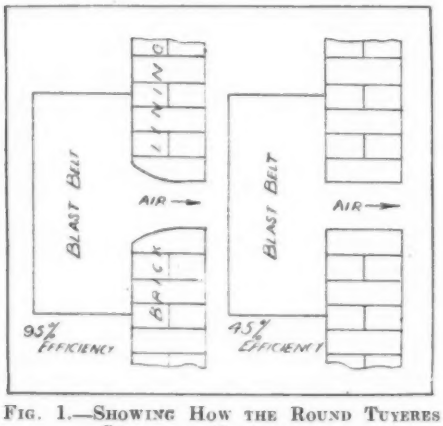


FIG. 1.—SHOWING HOW THE ROUND TUYERES SHOULD BE CONSTRUCTED.

does, chill the slag and so causes a "bung-up" of the cupola. To have a low coke bed is not everything. Then, again, the flat, continuous tuyere readily causes the slag to "bridge" over the tuyere.

It is an excellent tuyere for rapid melting, and gives good results when not placed too low, and "bridging-over" above the tuyeres is not allowed to occur. When round tuyeres are used, the opening next the blast belt or blast pipe should be greater in diameter than the opening into the cupola (Fig. 1). In fact, it should be trumpet-shaped, and right-angles avoided.

Interior Modifications.

If the modifications in the interior of cupolas are considered, it will be found that almost the only change which has taken place relates to the portion immediately above the hearth and terminating a few inches above the upper tuyeres.

At this point there is an increase of diameter, and this is carried in a straight line to above the charging door. If any taper be given to the cupola lining, it should be in favour of an easy descent of the charges. Although built straight, a gradual increase of diameter from charging door to melting zone takes place in all cupolas, caused by the abrasion of the heated brickwork by solid iron and by the heat of the melting.

There is a common belief amongst foundrymen that the contraction of a cupola at the tuyeres is primarily intended to reduce the quantity of coke necessary to form the bed for the first charges of iron. That is a very important function, no doubt, and not to be undervalued, but the greatest benefit obtained is that of getting the blast right to the centre of the cupola. This results in a very intense and rapid combustion over the whole area of the circle, and not simply a local combustion in front of each tuyere. In lining such a cupola, and afterwards in fettling it, care has to be taken that the change from the small to the large diameter is made with a gradual slope, and not by a sudden change from the one diameter to the other, thus forming a circular shelf on which the descending coke may hang and so leave the space in front of the tuyeres hollow. In such a case, the result would be a "bunged-up" cupola. This is caused by the slag being cooled by the blast, with the result that it solidifies across just where the reduced diameter begins.

For successful work, the slag in all cases must retain its fluidity as it drops past, and away from, the cooling action of the blast.

The reduction of diameter mentioned is really a lengthening of the tuyeres towards the centre of the cupola, and there is an intense combustion extending over all the circular area of the cupola.

A double row of tuyeres gives the necessary tuyere area for the entrance of the blast, and will melt more quickly than tuyeres of equal area congregated at one level.

The higher tuyeres supply the necessary oxygen for the combustion of the carbon monoxide generated immediately above the lower tuyeres, the completed combustion taking place in the melting zone.

The melting zone of a 36-in. cupola, with two rows of tuyeres and a blast pressure of 8 oz., begins at about 6 to 8 in. above the upper tuyeres, and extends vertically for 24 in., and then terminates abruptly.

One row of tuyeres of suitable area will melt perfectly hot iron, but will do it more slowly than two rows of tuyeres. Two rows of tuyeres melt hot and fast.

Effect of Three Rows of Tuyeres.

Three rows of tuyeres will also melt hot and fast, but the upper or third row cuts up the lining badly and necessitates a deep bed of coke. Some maintain that no harm is done, although these upper tuyeres have no coke in front, but blow on to the iron. The idea is that the carbon monoxide which may be escaping from the melting zone, unconsumed, is met by this stream of air and is burned to carbon dioxide, and the economy of complete combustion obtained. It is doubtful if complete combustion in the cupola is wholly economical. On the contrary, a margin or slight excess of free carbon monoxide will ensure that the oxidation of the iron and the valuable metalloids present in the iron is reduced to the lowest degree possible. If a third upper row of tuyeres is to be used, then the pipes leading to such tuyeres should be of very small diameter—not exceeding 1 in.—and should connect to a tuyere of 2½ to 3 in. dia., so that the air may enter the cupola at reduced pressure, and thus minimise the cutting action of the flame at that place. The disuse of a third upper row of tuyeres does not affect the consumption of fuel adversely, retards the melting speed but slightly, and avoids a very rapid destruction of the lining.

Cupola Stack.

The appearance of the flame at the charging door, when melting is being done, is an excellent index as to whether the cupola is being worked to the best advantage. The cupola stack or chimney should be of sufficient area and height to take away all the escaping gases and flame from the charging door, and so help to make more comfortable the charging of the cupola, which, under the best conditions, is always a laborious operation.

The cupola should be sufficiently high between the upper tuyeres and charging door to allow the ascending flame and products of combustion to part with their heat to the descending charges of iron and coke. Unless during the final 25 or 30 min., when charging has ceased, the lining of the cupola at the charging door should not be hotter than a black-heat, or at most a dark-red heat.

Lessons from Flame Conditions.

There should not be, as is so often seen, a continuous "flaming-up" through each topmost charge put on. This continuous flaming-through is to be avoided as being a waste of heat. It is a combustion which should take place very much further down the cupola, and is, indeed, only rendered possible by the charges of coke being sufficiently large to stand this waste of heat and yet have enough calorific power left to do the work in the melting zone. It is a "consummation devoutly to be wished" that the coke would descend, only gently warmed, to within two feet of the melting zone, there to begin to redden up ready for the work of melting shortly to begin. For coke to get red hot, perhaps eight feet above the melting zone, is gross waste of fuel, heat and money. In hot weather it also renders the position of the men charging the cupola almost unbearable.

The flaming through the upper charges may also be attributed to deficient blast, or blast badly distributed, and the same result will ensue with a cupola which is too short. There may be flame in the chimney stack immediately above the charging door; in fact, there usually is such a flame, but the heat from it causes little inconvenience. This flame is the burning of carbon monoxide, probably from the incandescent coke just above the melting zone, and is characterised by being of a bluish-pink colour, the flame clinging to every little projection and ledge in the chimney stack. When the flame in the chimney is of this bluish-pink tinge, the blue predominating, the flame clinging to the chimney wall, as mentioned, now and again running down and burning at an opening in the charge in a ragged sort of way, then it is scarcely necessary to look at the metal being drawn from the cupola. Such an appearance at the charging door always betokens that good melting is being done. A flame of whitish-yellow colour, extending through the charge and up into the chimney and often out at the top of the chimney, and without the ragged appearance of the proper flame, indicates that too little air is being blown into the cupola. This flame may be seen in a cupola with proper blasts any time the cupola-man opens a tuyere to clear away any obstruction there may be in front of the tuyere, and so allows some blast to escape, thus temporarily reducing the blast pressure. This flame is also an indication of scaffolding or other obstruction to the free passage of the blast. When the flame appears and the blast-gauge indicates a rise of pressure, then it is well to see if scaffolding has begun.

The appearances thus roughly indicated are such as apply to a cupola measuring 14 to 15 feet between tuyeres and charging door, and give, as indicated, a good idea of the general conditions obtaining in the cupola at the particular moment.

The total tuyere area to be economically employed is governed by the diameter of the cupola, the blast pressure available, and the density and quantity of the coke used.

How to Deal with Poor Coke.

Whatever be the diameter of the cupola, it is desirable to have the blast effective over its whole area. If the diameter be large, then a higher pressure of blast may be used effectively to reach the centre of the cupola; but the coke must be hard and dense to be satisfactory under such conditions. With a softer coke, the tuyere area has to be enlarged so that the proper volume of air may enter in a given time. This stream of air being slower moving, and having a larger surface contact as it enters the cupola, has not such an abrasive action on the incandescent coke as the stream from a small tuyere.

Should the tuyeres be set for high pressure of blast and dense coke, and coke of low density be delivered by the makers, as will sometimes happen, it is best to blow with less pressure. Melting will be slower, but the cast may be performed, though later than usual. Hard blowing with soft coke results in the bottom part of the cupola in front of the tuyeres being blown hollow, a solid roof of set slag, a few inches above the tuyeres, a "stuck" cupola, and a general mess. There is no single thing which can happen in foundry operations which so nearly affects everyone as a "stuck" cupola. It is a serious financial loss to both employer and employed, and raises a grave suspicion of the capacity of the management should it be anything but a rare occurrence. On the other hand, there is room for just a little legitimate pride when one has mastered the varying conditions attaching to cupola melting, and made the cupola a willing slave, answering to every call made upon it.

Pressure and Volume of Blast.

In recent years there has been a considerable change in opinion of foundrymen as regards the best pressure of blast to use. Some years ago the tendency was towards small tuyeres and high blast pressure. This, no doubt, was due to the desire to get the blast to the centre of the cupola and so help to make the whole cross area of the cupola to do effective melting.

Opinion has now largely swung round towards larger tuyeres and low blast pressure. To show the large difference of blast pressure which may be used, it may be mentioned that one cupola was melting at 4 oz. pressure and another 32 oz. pressure. The latter was certainly too high, and they were troubled with hard castings. For most purposes, 12 to 14 oz. pressure is sufficient. It may be accepted as a rule for blast pressures that, if soft castings are desired, then blow softly, but if dense or hard castings are required, then blow hard.

It is now realised that the *volume* of blast admitted to the cupola is the more important. Recent cupola records show that for good combustion approximately 30,000 cub. ft. of air are required for each ton of iron melted. This is in accord with generally accepted facts.

There is a more intimate connection between pressure and volume of blast, and the quality of the castings, than is ordinarily realised. If charges of coke are heavy, and the air supply less than it should be for the coke available, then one may add free carbon to the iron. This results in "kishy" and dirty castings.

If the coke charges are lean, and a large pressure and volume of air is employed, then the castings are made dense and hard. One may want to make castings soft, or perhaps they may be wanted dense or hard. Either may be done to a very great extent by the relative proportions of coke and air. When the air supply is not sufficient to combine with the free carbon of the coke, then the iron will dissolve some of this carbon and give it back as "kish" or dirt in the casting. When the supply of coke is lean, and the air supply is in excess of the carbon available in the coke, then the excess air is liable to combine with something. It combines with—that is, oxidises—some of the silicon, manganese and carbon in the iron, and perhaps the iron itself. Thus one gets hard castings. To put it concisely, a mixture of metal should come out of the cupola as intended, and that is neither softened nor hardened. This can only be done by a balance between coke used and the proper supply of air for that coke. No fixed rule can be given as to what these proportions should be. The different conditions under which melting is done, and the requirements are so various, as to make the fixing of a rule impossible. Only by trial can the best conditions be found in each case. There should be a blast gauge on all cupolas and attention given to the readings. Not to have a blast gauge on a cupola is no more sensible than not having a steam gauge on a boiler, only the latter is more dangerous. The considerations advanced as to the very great effect of the blast upon the quality of castings, an effect very little realised at present, may result, it is hoped, in the more extended use of the blast gauge.

Scaffolding, and How to Avoid it.

Scaffolding is the term used when the charges of coke and iron have ceased following down as the coke and iron previously charged is burned away and melted respectively. When scaffolding occurs in a cupola, there is usually a fairly empty space in front of the tuyeres. Over the tuyeres, however, and extending almost, if not quite, across the cupola, is a roof of solidified slag and iron.

Scaffolding may be due to deficiency of fluxing

material, such as limestone or fluor-spar. Under such conditions the slag formed is pasty and not truly fluid, with the result that, when it comes within the action of the blast as it enters the cupola, the slag speedily changes the pasty for the solid condition. Poor coke, having low carbon and high ash content, associated with low density of structure, otherwise a light coke, is a fruitful cause of scaffolding. The low carbon-content does not give that intensity of heat so desirable; the high ash gives excessive slag, and the lightness of structure allows the coke to be readily disintegrated or blown away by the blast. Faulty contour of cupola lining, possibly in conjunction with the causes just mentioned, may cause, or help to cause, scaffolding. All departures from vertical lines, or where cupola linings are being drawn in at the bottom, should be done very gradually, and anything in the nature of a shelf carefully avoided. Blowing a cupola with too much blast may also cause scaffolding, but that is a comparatively rare cause where good coke is employed.

The way to avoid scaffolding is just the converse of the causes mentioned. Have ample fluxing material, say 56 lbs. of limestone per ton of iron melted. If charges are all pig-iron, 40 lbs. of limestone per ton of iron melted is sufficient, but then, few founders use all pig-iron. Use good coke, with carbon as much over 90 per cent. as can be obtained at a moderate cost. The lessened melting power of a coke of 87 per cent. carbon is very marked as compared with coke with 90 per cent. carbon. It takes 27 cwt. of the 87 per cent. coke to supply as many carbon units as is contained in 26 cwt. of coke with 90 per cent. carbon. Ash usually takes the place of carbon in low carbon cokes, and it is a very poor substitute. The only place where it is as effective is on the weighing machine.

If low carbon coke must be used, and scaffolding is to be avoided, then ample fluxing, light charges of iron, and easy blowing are the means to adopt.

Coal and Tuyere Stopping Methods.

If a piece of pig-iron or heavy scrap has reached the front of a tuyere, it forms an excellent nucleus for scaffolding to begin. The large door in front of the tuyere provides a means by which some pieces of coal may be placed in the inner end of the tuyere, against the hottest fuel or slag there, so that the coal may begin burning. If the pig-iron or scrap (it is usually a piece of pig-iron) blocks the way, then it must be poked back towards the centre of the cupola, so that the coal gets alight. The tuyere is now closed and the blast allowed to blow the lighted coal. Such a course has usually a magical effect in clearing the tuyere, as the flame from the coal is very hot. A large door to the tuyere allows the coal to be put into the tuyere by the hand. With a small door, the coal has to be thrown across the air belt, with the result that about one piece in six reaches where it is wanted. If the unmelted pig-iron or partial scaffolding cannot be moved back by the steel bar in the hands of the cupola-man, then the tuyere should be closed by means of ganister or other suitable material, and the other tuyeres be made to melt down the obstruction. The blast should be eased while this is being done, and not put on full until, by poking a hole in the tuyere closed with ganister, it is seen the obstruction has gone. The tuyere may now be fully opened and the blast put full on, and melting proceeds as before.

If several tuyeres have got black, and the obstruction cannot be moved by poking nor by adding coal, nor by stopping tuyeres, it may be concluded that the cupola is in a "parlous state." In such a contingency, shut off the blast at once, as more air is only cooling the cupola and making it more difficult to get out the coke and iron. The cupola-men may now experience the dismay of getting the coke and iron, some of it half melted, out of a "bunged" cupola.

Putting extra limestone or other flux on the topmost charge is of use only if the scaffolding is cleared and melting is proceeding; in this case the added limestone as it reaches the melting zone will render the slags being formed there more fluid, and so help to clean down the walls of the cupola. When the cupola is cleared of the unmelted charges there is always a good quantity of slag and iron adhering to the lining of the cupola. If the cupola has to be fettled next morning, the cupola-men, with anxious forethought as to how hot it will be, will sometimes, if allowed, throw quantities of water through the charging door on to the hot brickwork and thus ruin the lining. A better plan is to close the charging door for the night, and allow the air to travel the whole length of the cupola from bottom to chimney top. Leaving the charging door open in the expectation that it will let out some of the heat is a mistake; it only spoils the draught to be obtained by the unbroken continuity of cupola and chimney.

Comparison of Types of Cupolas.

It may be useful to compare the relative drawbacks and advantages of cupolas which have solid bottoms, collecting the metal in their own hearth, and those having drop bottoms, and having separate hearths or receivers. Cupolas which have solid bottoms and collect metal in their own hearths are less expensive to erect, less costly in upkeep of lining, etc., and require less fettling daily. The coke has to heat up, say, 30 cwt. less of brickwork than in the case of a cupola having a receiver, and so has that heat to bestow on melting. A given quantity of coke should thus produce hotter metal at the tap-hole of a self-contained cupola than will be tapped from one having a receiver, and this is undoubtedly the case.

The tuyeres of a self-contained cupola, however, as already pointed out, have to be sufficiently high to allow a body of metal to be collected in the cupola, and this causes the bed of coke to be higher than is necessary in a cupola having a receiver or separate hearth.

Contracting the cupola in the region of the tuyeres so as to get blast penetration also reduces this capacity for holding a quantity of molten iron. In this respect the cupola with a receiver has an advantage. No metal being collected in the cupola, the size at bottom may be reduced very considerably, and so the coke used for the bed may be lessened accordingly.

Cupolas having receivers allow a more perfect mixing of iron, as a large quantity may be collected in the receiver with no risk of having trouble with iron or slag getting into tuyeres. This collecting and perfect mixing of the iron is the outstanding advantage of the use of a receiver, and renders possible the drawing in of the cupola as mentioned. It has no other advantage. Besides, the channel-way or connection between cupola and receiver, through which all the iron and slag flow, is a distinctly tender part. If a crack develops and the metal begins to come through, and in doing so proceeds to cut up the iron casing, it is almost impossible to go on melting.

The author has found it best not to run the metal along the main connector brick. By bedding good fire-bricks end-to-end along the channel, and renewing these as they get worn out, a very much longer service is got from the main brick. Should the metal get between the joints of the bricks, it can get no further than the connection or main brick on which they lie. Should the connection brick get cracked, say, by a movement of the receiver, and in heating and cooling this is not unusual, then by making one of the fireclay bricks to span the crack, the connection brick may be made to do service until it can be suitably replaced.

To sum up in a few sentences what has been stated, a cupola which collects the metal in its own hearth or bottom will melt metal more economically than one having a receiver or separate hearth, but will require higher personal skill in management to produce well-mixed iron. A cupola having a receiver takes more fettling to keep in order, is not so economical of fuel, having a larger body of brickwork to heat up, but gives more perfectly mixed iron.

Drop-Bottom Cupolas.

Cupolas with drop bottoms are common in this country, but most founders prefer those with solid, brick-built bottoms, the coke, slag, etc., being

drawn out at the side door at bottom, at the conclusion of the cast. Some who have had drop bottoms to their cupolas have even discarded them and built solid bottoms instead. Drop bottoms are in almost universal use in America.

Drawing a cupola by the side door at bottom at the conclusion of a cast, as is necessary in cupolas having solid bottoms, is laborious, hot work at the end of a hot day.

How to Stop a Leak.

With a drop bottom the contents of a cupola may be withdrawn in two minutes without any effort worth mentioning. On the other hand, the drop bottom has to be made up each day, and made up carefully and well. A solid bottom cupola requires practically no making up whatever. When metal happens to make its way down through the folding doors of a drop bottom, as will sometimes happen, there is no necessity to drop the cupola. The way to stop the leak is this: turn off the blast, take off the door in front where the kindling is put in, and dig away the sand forming the bottom, in the direction where the metal has been coming through. When the spot is reached, ram in some good tough sand, and continue ramming until the dripping ceases. Then make up the front door and proceed with the melting. A moulder does the ramming better than anyone else, as he knows exactly the effect he is producing in making the bottom firm and solid. The operation of stopping the leak and beginning again need take no longer than fifteen minutes.

It is to be observed that on such an occasion the bottom doors are not dropped, the sand being rammed betwixt these doors and the partially-fused sand forming the surface on which the metal has dropped when melted. One material advantage the drop bottom has over the solid bottom is when more iron has been charged into the cupola than is necessary to cast the work then on the moulding floor. When all the iron required has been tapped out, the blast may be turned off and all the unmelted iron and unburnt coke in the cupola dropped, the coke being carefully quenched, to be used again the following day. In such a case, when using a cupola with solid bottom, the cupola-men almost always melt the iron and pour it on the floor. It has then to be broken up, is accounted as scrap, and is charged into the cupola as such. The coke used in melting this excess iron is consumed, of course, and is not again available.

Weight Considerations.

The cupola-man's motive for doing so is not to waste the coke or iron, but is simply that for him the easiest way to get out of a solid bottom cupola iron which is already in is by melting it out.

Charging exactly the quantity of iron required is excellent foundry practice, but having 1 cwt. less than is required is very bad practice indeed, and may result in the "pouring short" of an important casting. If there is any doubt of the quantity of metal in the ladle being sufficient for the mould to be cast, and no more is to be had, then do not hesitate to pour the metal into pigs made in the floor. It is the most stupid of proceedings to follow an error in judgment at the cupola by turning a good mould into a very indifferent pig bed. That is what is done when a mould is poured with too little iron, and is not at all an unknown feature in some foundries.

A few hundredweights of iron in the cupola in excess of the probable requirements is thus used as a factor of safety, and, as already pointed out, the drop bottom allows this margin of safety to be obtained at the cost only of picking out the iron and coke from the debris of the cupola and elevating it to the cupola platform.

One additional advantage the drop bottom has is the easy access it gives to the interior of the cupola for fettling purposes. There is thus a clear balance of advantage in favour of the drop bottom as compared with the solid bottom cupola for ordinary foundry work.

Cupola Management.

By cupola management the whole conditions brought into effective use to produce economically, by means of the cupola, the best metal suited for the casting to be made are implied.

Iron may be melted with a very low ratio of coke to iron, and yet not be economically melted. If the iron is not sufficiently fluid for the particular work to be cast, then a small consumption of coke per ton of iron melted has been waste and not economy.

Cupolas are too often left to be managed by practically unlettered men, to whom "use and wont" is the only safety, and deviation spells disaster. To look to such for an advance in cupola practice is folly. On the contrary, the best powers which can be brought to bear on the subject may have full play without exhausting the wonders of cupola processes. The advance of knowledge regarding these is the only way to mastery.

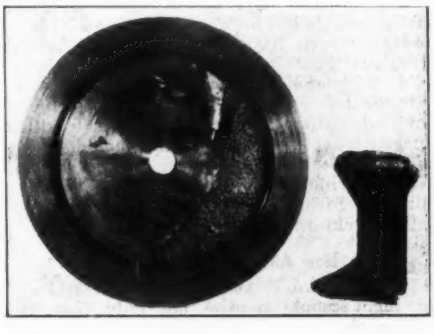
One of the things it is hoped the future contains is that no one shall be put in charge of a foundry who cannot himself, in some considerable degree, supply some of that higher knowledge which fate, or providence, has denied to those under him. Then we may hope for a permeating of this knowledge down through the several grades of the workpeople, with the resulting advantages which such knowledge would surely give.

(To be continued.)

Foundry Queries.

A Brass Foundry Waster.

Could you advise me of the cause of the splitting of the brass casting illustrated? I have had quite a number of these cast, all from the same pot.



They were moulded face-side up, two in a box, and skin dried. They were made from medium-weight brass scrap and about 25 per cent. returns The runner in each case throws back instead of sinking.—C. O. R.

From an inspection of the casting it is obvious that the metal, on making contact with the face of the mould, froze and afterwards sank, due to the presence of more than an ordinary amount of gas. We would suggest that the metal had been overheated during manufacture, or that materials of a poor character had been used.

A New Fordath Oil and Sand Mixer.

In our issue of June 15 last year we gave an illustrated description of an oil and sand mixing machine, manufactured by the Fordath Engineering Company, Limited, of Hamblet Works, West Bromwich. This machine was then a novelty, and quickly found a ready sale. It will be remembered that at this period only one size—5 cwt.—was made, and it was soon realised that this was too big for the smaller foundries. The firm have therefore designed and put upon the market a smaller machine built upon identical lines to the one we described. The new pattern, however, mixes 2 cwt. at a time, and requires but 2 h.p. It will be recalled that these machines mix the material very thoroughly in 5 mins. A point worthy of notice is that some firms prefer to install two smaller machines in place of one larger one on account of the greater elasticity afforded, when several grades are required simultaneously.

Aluminium in Steel.

Some time ago we assisted in some experiments on the influence of aluminium on steel. These experiments were based on the assumption that, owing to the lightness of aluminium, a fair quantity burnt on the surface of the metal or reacted with the slag and not the oxides in the metal bath. The method used was to attach aluminium bars firmly to an iron rod or spoon and plunge it *beneath the slag*. Obviously, minor difficulties were at first experienced as to the method of securing the aluminium, but once success was achieved, good results were forthcoming. No alumina inclusions were found, and as a method of dealing with a boil off the bottom of a furnace, it was an unqualified success. MR. W. H. KEEN, writing in a recent issue of the "Iron Age," confirms much of our experience. The following is an abstract of his views:—

Why is it that protests are so numerous against use of aluminium in the killing of steel? The recent literature seems crowded with adverse criticism, with almost never a word of commendation. The use of aluminium results in decidedly more and greater advantages than disadvantages, and, in fact, the writer goes so far as to say that its use is exceedingly desirable, almost necessary, to produce a clean, sound steel. It is true that photomicrographs have been published showing inclusions of alumina as the cause of failures, and, while these data are important, and should be given due consideration, yet the accompanying information as to manufacturing details is all too meagre to use the information in a scientific analysis of the problem.

A small amount of aluminium in the ladle and in the moulds has been used because no bad results had ever been traced to its use and because, on occasional heats which were inclined to be a little wild, it quieted the metal and saved the ingots.

Ingots of soft steel particularly (0.10 to 0.15 per cent. carbon), when not completely killed, will sometimes actually boil in the mould, even after the initial set of the surface and several minutes after pouring. A few small pieces (less than an ounce to 1,000 lb.) thrown in during the pouring will prevent this entirely.

How Additions Should be Made.

Pieces of aluminium thrown into metal rising in an ingot mould oxidise not only from reaction with carbonic gas and oxide impurities in the steel, but also with oxygen from the air, as the small pieces float about for an instant on the surface of the metal and then become entrapped.

Aluminium should be added in the furnace before tapping, and should be immersed completely in the bath. In this manner all of the desired effect of the reaction is obtained, and none of the undesirable results. Aluminium is also beneficial in electric steels, but smaller additions will accomplish the end desired.

The thermit reaction is utilised to-day in the preparation of many important metals, and no objection has ever been made to use of these metals in steel because of their aluminium content. In this reaction, aluminium has shown itself to be a very powerful reducing agent, and, in addition, to react so consistently that conditions are always under excellent control.

Oxides are the principal non-metallic impurity in steel—all steels, particularly open-hearth and Bessemer. The ordinary reduction with silicon and manganese in the natural way, is effective, but almost never perfect, and varies according to the skill of the melter and other conditions due to the mixture used, temperature of the furnace, and action of the slag. If aluminium will reduce such metals as tungsten and vanadium so perfectly, why should it not be applied to steel?

Other Advantages.

It has other advantages incidental to its use when added to the bath. The analysis can be kept in much better control. In the case of the open hearth, the addition of 2 to 4 lb. to the ton, according to condition of the bath, will stop the boiling reaction instantly, and the bath will lie perfectly quiet as long as the aluminium is in excess. The carbon remains practically constant under these conditions, and any slag which may have been taken up by the metal has abundant opportunity to rise to the surface before the heat is tapped. Guesswork on re-carburising is eliminated, as the laboratory test of the bath is of much greater value than under the usual conditions where the reaction is allowed to continue.

Experiments were made increasing the quantity of aluminium added up to an amount found by analysis of 0.37 per cent. The object was to determine any bad effect of the aluminium on the steel. Tensile tests showed a slight improvement with every increase in the amount used, and it was judged from this that the additions were not harmful. Several lots of aluminium used were found to contain small percentages of zinc. When so contaminated, the results were poor. Zinc is often found in aluminium reclaimed from scrap, and should be guarded against carefully.

No substitute for aluminium has yet been found, but recently a new alloy (calcium silicide) has appeared on the market with similar claims for its performance. This alloy has merit, but, in its present state of development, has to be added to the ladle. It would be interesting to make a direct comparison with aluminium if it could in some way be introduced effectively into the bath.

Steel deoxidised by large doses of aluminium will be found very clean and dense, and will work up with a minimum of chipping or grinding and mill losses. The improvement is particularly noticeable on nickel-chrome and chrome steels.

The writer realises that the foregoing statements will probably meet with considerable adverse criticism from many sections of the country, but he considers the results important, because they contradict a well-established prejudice.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Non-Ferrous Electric Furnaces.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have noticed in your issue of December 21 an extract from the "Iron Age" entitled "New Installations of Electric Brass Furnaces," in which you state that "The British non-ferrous industry is making but slow progress with the electric furnace, due to the high cost of electricity."

So far the rate of progress has certainly not been rapid. Two Ajax-Wyatt furnaces, each of 600 lbs. capacity, are in operation in Birmingham, and a firm operating one of these has just ordered a second furnace of the same size, but I do not agree that the high cost of electricity is chiefly responsible for the slow progress. A variation of one-tenth of a penny per unit of electricity makes a difference of only two shillings per ton of brass melted, so that the cost of power, though it is of course an important factor, is not so vital as appears at first sight. The price of power at most of the works in America, where electric furnaces are extensively used, is about the same as in this country, and as 2,500,000 lbs. of brass per day is being melted in Ajax-Wyatt furnaces in the United States, some other reason must be found.

I believe that by far the most important cause is the prolonged depression in the brass industry, which has made it difficult to find money for new plant. The desire of British manufacturers to let some other firm prove the process successful in this country before trying it themselves has also been evident, but now that conditions of trade are improving and electric furnaces have been running long enough in this country to prove their success, it is probable that in 1923 the tonnage of brass melted electrically in Great Britain will be very greatly increased.

Yours faithfully,

W. S. GIFFORD.

17, Victoria Street, London, S.W.1.

KAWAHARA & COMPANY, LIMITED, have removed to 21, Mincing Lane, London, E.C.3.

Institution of British Foundrymen.

EAST MIDLANDS BRANCH.

Discussion of Mr. E. Longden's Paper on Gating, Feeding and Casting.*

THE PRESIDENT (Mr. Evans) said the Paper raised many points in which his own experience had led to practically the same results. His experience confirmed the author's that it was necessary to run all castings as quickly as possible, which makes for success in grey ironfounding. The whole question of grey iron foundry practice is based on graphitisation, which means that if a casting is not run sufficiently quickly the thin sections will be hard. The author apparently runs all his castings as quickly as possible, making the temperature in the mould about equal all through, and there is no chance of unequal solidification. There was one thing to which he could not subscribe, and that was the running of a casting on end. With reference to the oxidation of the iron, he could not agree that this took place, because if the percentage of silicon is very high there is no need to trouble very much about oxide in grey iron. Many of the gases which become trapped are the result of gases from the mould, and this gas is sometimes evolved very quickly, forming a pocket in the mould which fails to escape. Filling up risers with hot metal is another strong feature, for it is impossible to carry out successful malleable founding without adopting that practice. A successful method shown by the author for running a light casting had been tried by the speaker for plain ring castings during the war. They gave trouble with running, but by adopting the same method of running tangentially and pouring as quickly as possible, success was achieved.

Italian Practice Discussed.

MR. SHEARS said he was interested in the castings made in Italy. The author mentioned phosphorus gave increased fluidity, but there was 0.3 per cent. phosphorus. How did it happen that they had at the same time fast running?

MR. LONGDEN said he gave simply the results of a successful way of running a heavy casting as practised by the Ansaldo firm. The metal must be well melted. The silicon is low, but, on the other hand, the other constituents are high, and it shows particularly a high total carbon content.

THE BRANCH-PRESIDENT said it was a good analysis for the casting with a low silicon iron. One must, however, make gates sufficiently wide. The Italians were running a low phosphorus iron, but 3.81 per cent. carbon, which is high for a low silicon iron. It is good practice to increase the phosphorus and decrease the carbon, because usually the lower the graphite the smaller the flakes.

MR. LONGDEN said that in Diesel cylinders and heads it is advisable to have a high carbon content on account of the great temperature these castings are subjected to when working.

Hot Casting Favoured.

MR. S. H. RUSSELL hoped the Paper would appear in print, so that they might consider it more carefully. He agreed that hot casting is the first essential in the foundry. Some of the pouring speeds Mr. Longden gave for castings weighing as much as 10 tons—two or three minutes—are rather amazing to some who do not handle such large work. One might ask how it was possible to get 10 tons of metal into the mould in practically 120 seconds. He would also raise a point that it was essential to consider where to put the riser on small castings, *e.g.*, in machine-moulded pulleys. The tendency is to put a riser on the bosses—whether necessary or not, that practice is fairly common. The result is the pulleys often crack in the arms. More heat is concentrated in the boss, thus increasing the risk of the arms cracking. It is frequently possible to cast pulleys without a riser or runner on the bosses, and thus save the pulley from cracking. He had frequently had instances where much trouble was saved by keeping the runners away from the heavy parts. He was particularly interested in the cracked plate weighing 40 tons, and would like more information, as it was of general interest. Mention has been made of the iron used for the large Diesel engine casting made in Italy. The aspect which appealed to the speaker was not the phosphorus content, but the sulphur (0.28 per cent.), as he had found that 0.08 per cent. was the limit if trouble was to be avoided.

How Fly Wheels are Run.

Replying to Mr. Russell, MR. LONGDEN said that the quick running of a flywheel of about 10 tons is only a matter of arranging the area and number of runner-gates according to weight of casting. The boss is partly filled by lifting one stopper, then the remainder of the plugs are lifted, allowing a rapid filling. This is normal practice. The circular runner around a pulley rim is the best way to get such a casting, but is, of course, expensive. Regarding the 40-ton plate which cracked, he utilised this more to create discussion than for anything else, as he was seeking information himself. The next one was moulded a little differently, and a sound casting was secured. The runners were directed more to play on the outside of the plate. The centre of the plate was bared.

The sulphur content given in the analysis of the Ansaldo iron is certainly high.

MR. WORCESTER, speaking about the plate, said he had in mind a similar occurrence for a gas engine weighing 20 tons, which broke through the centre. The trouble was overcome by putting a large core in the centre of the plate. The flywheel mentioned was not, he presumed, fed on the boss, but run from the run. He had made a large wheel having 2 ft. of metal in the boss and 2 ft. on the rim. It was 12 in. deep in the arm. Local feeding was quite necessary. These castings could not be overcome by casting in another position. In the Midlands dummy risers were said to remove dirt, but this is not so, if put on the top of the casting. He agreed that they would sometimes carry the metal up into the sharp corners.

MR. LONGDEN said a flywheel of 2 ft. boss section would certainly be a heavy casting. He had never seen one. His experience was that flywheels with bosses and rims averaging about 9 in. sections, with arms 8 in. by 7 in., are substantial castings. There is ample area to allow the movement of the metal from rim to the boss for some considerable time.

French Risers.

With regard to the "French" risers, he did not agree that one can, to a very great extent, clear the top side of a casting by employing such a riser. Immediately the metal touches the top side of the mould the dirt will accumulate and stick there, and the clean metal flow underneath. He was surprised that his remarks on pressure were not appreciated. As a matter of fact, the increase in the height of a column of metal does not make a great deal of difference in the specific gravity of the iron. Of course, it does to a small extent, but it did not appear to be pronounced. Pressure is a great help to the vents. If there is a low head of metal, the gases more easily travel through the shorter depth of metal. With a deeper head the tendency is to press the gases in the direction they should go—that is, to the vents.

MR. STEVENSON said he did not care for tapered runners, as it was better to provide for parallel runners for the sake of speed and pressure. Metal from tapered runners very often causes scabs. He agreed that the inlet or the spray should be certainly of larger area than the down stick.

Button Risers.

Mr. Longden showed a method of eliminating buttoning risers. He supposed the way was to scrape some of the surface of the mould just round the riser, and leave on that quantity of metal. The button method is really the better way. Unless the riser is broken off very hot, the button very rarely breaks in, and is easily chipped off.

* This Paper appeared in the December 7, 14 and 21, 1922, issues of the "F.T.J."

XUM

Some moulders presume that a riser takes off dirt. He had never confirmed this, and any dirt in the mould will stay in. The first metal which enters the mould forms a thin skin round the shell of the mould. This is usually noticeable in a heavy run out, and the casting runs away at the bottom of the mould. In taking a mould to pieces, it will be found that it leaves a very thick shell, practically the shape of the casting. Any dirt in the mould will certainly fasten to that shell, and no riser will take it off.

He then proposed a vote of thanks to the lecturer.

MR. RUSSELL seconded, and THE PRESIDENT, supporting, said the author had tackled a subject which was essential for foundrymen, since the success of a foundry depended very much on the very things he had dealt with. There was a wealth of detail in the Paper.

After acknowledgement of the vote of thanks by the author, the meeting was closed.

LONDON BRANCH.

A joint meeting of the London Branch of the Institution of British Foundrymen and the London Local Section of the Institute of Metals was held at the rooms of the Institute of Marine Engineers, Minories, London, on December 14, 1922. There was a very large attendance. Mr. Wesley Lambert (President of the London Section of the Institution of British Foundrymen) presided, and was supported on the platform by Dr. D. Hanson (Chairman of the London Local Section of the Institute of Metals).

MR. LAMBERT, after welcoming the London Section of the Institute of Metals, called upon Dr. Longmuir to read his Paper on Brass, Iron and Steel Foundry Practice. This Paper was originally presented to the Newcastle Branch, a report of which appeared in our issue on November 30, 1922.

Discussion on Dr. Longmuir's Paper on Brass, Iron and Steel Foundry Practice.

MR. LAMBERT said that Dr. Longmuir in his address had brought out some very interesting points that the majority of metallurgists knew something about, and would like to know more. For instances, Dr. Longmuir had shown one slide illustrating solid contractions, but he (Mr. Lambert) regretted that a slide had not been shown giving the liquid contractions of metals. He had been looking for data in this connection for a very long time. With reference to "casting temperatures," he took it that, where they had such variations as were pointed out in the mechanical properties of metals, due to varying casting temperatures, the test-bars were all of uniform size. Dr. Longmuir had said there was no one casting temperature for all shapes and sizes of castings, and therefore variations in mechanical results might have relation to the size of the test-bars. He had been very interested in Dr. Longmuir's remarks with regard to the high tensile brasses, more particularly the statement that it was necessary to correct for zinc loss when remelting manganese-bronze, and especially so when melting in an air furnace, and also that furnace tests could be made by fracture, by the microscope and by rapid zinc determination. He did not know of anyone who was making use of the last method. He did not want to be egotistical, but he believed he was the first to adopt the microscope and metallographic examination as a means of determining the necessary zinc corrections at the furnace. That was done because, with the high-tensile brasses, especially those not containing tin, there was a great difficulty in differentiating between fractures when they were working within a very narrow range of composition. The high-tensile brasses containing tin exhibited more or less of what was called "sparkle," and the degree of that sparkle—always provided, of course, that the test specimens were cast under uniform conditions—gave a ready means of determining whether or not there was sufficient zinc in the mixture. When working with high-tensile brasses without tin, and within a narrow range of composition, there was not such a pronounced sparkle. The only method of which he knew that would give an accurate idea of the zinc losses that had occurred during melting down of a charge of manganese-bronze in an open-hearth furnace, was the microscopic method of examination.

Future of Aluminium Castings.

DR. HANSON, on behalf of the London Local Section of the Institute of Metals, thanked Dr. Longmuir for his address. Dr. Longmuir had referred to the great progress that had been made in casting generally during the past few years, and perhaps he (Dr. Hanson) would be permitted to add to what had been said. There was no doubt that now we can cast a number of materials with great success which we could not tackle a few years ago. At the beginning of the war, for example, great difficulty was experienced in the casting of cupro-nickel, and a large amount of work had had to be done before the casting of that somewhat difficult alloy could be placed on a firm basis; but we had tackled it, and had been very successful, reducing the scrap to a negligible quantity. Perhaps more notable still was the advance in the casting of light alloys of aluminium, which had come to be used in recent years on a large scale, particularly for aircraft purposes. The developments in the casting of light alloys were truly remarkable, and there are now alloys available, which are not so well known, perhaps, as they ought to be, which would compete very successfully with brass and bronze castings. It is now quite possible to get castings that will give a tensile strength of over 20 tons per sq. in., as cast and heat treated with a very considerable elongation.

Development of the Y Alloy.

Particulars of the 21-ton alloy, known as the Y alloy, had been published in the last report of the Alloys Research Committee, and he believed it would be admitted that the development of that alloy was really a notable achievement. If the brass industry were to progress, it must take note of the remarkable advances made with these light alloys. He knew that Dr. Longmuir did not regard casting temperature essentially as its influence on the strength, but as the effect of different conditions of casting on the strength. He would have liked Dr. Longmuir to have gone into that a little further, and had tried to give some reason for that difference which occurred as the result of the variation of casting conditions. But Dr. Longmuir had given a clue when he plotted conditions of casting against "watertightness." There, he believed, they had the reason for the difference. Some of the castings were not watertight, they were unsound, and surely that was why the alloys did not give good strengths. Sometimes unsoundness was due to gas evolution during solidification. Copper was a case in point, and aluminium alloys were often unsound for that reason. In other cases it was almost entirely a question of shrinkage during solidification. A metal that had a large contraction during solidification was likely to leave gaps between the different crystals that grew while the metal was becoming solid, and unless the conditions were so arranged that liquid metal could flow in and fill the gaps continuously, unsoundness would result. The question of gas evolution during solidification was really a very important problem, and one which was, so far as he knew, absolutely untouched.

Effect of Impurities.

The conditions governing the evolution of gas during solidification were unknown. In some cases, the amount of that gas that was required to ruin a casting was insignificant in weight compared with the weight of the casting. If it were regarded as an impurity in the metal, it represented a quantity that could not be measured, but it did untold harm. Referring again to copper, pure copper was an exceedingly difficult metal to cast; it rose in the mould, and often resembled a sponge more than a casting. This metal was about as pure a metal as could be got, and the reason was not known, but there was some reason to believe that it was connected with the sulphur content of the copper, and partly with the oxygen. It was generally considered that by regulating the amount of oxygen in copper a sound condition

could be obtained, but he did not think that was the complete story, and some recent work published by an American worker had indicated clearly that it was not only the oxygen that was important, but the sulphur, and the lower they could get the sulphur, the less oxygen was required to give a sound casting. If they could get rid of the sulphur entirely, it was probable that they would not need oxygen to give soundness. The amount of sulphur concerned in having that effect was extremely small, much less than 0.01 per cent. An amount of sulphur of, say, 0.005 per cent., would have an appreciable effect on the soundness of the casting. He had raised that merely to show that, in dealing with some of these problems, they had to look for what were apparently the most insignificant things. That indicated that one of the most important problems to be studied was the effect on the castings of the impurities that were normally present in metals.

Metals Have Same Viscosity as Water.

With regard to fluidity, he was not sure what Dr. Longmuir meant by "fluidity." It was very generally stated that some metals ran in a sluggish manner, and others very freely. The cause of that was another puzzle, because he believed that if they measured the viscosity of liquid metals—he was not sure that that was what Dr. Longmuir meant—it would be found that the metals did not differ very greatly, and, strange to record, liquid metals were not very much more viscous than water; yet there was, no doubt, a difference in the running powers. Could Dr. Longmuir say anything about that? It was possibly connected with the oxidation of the surface of the running metal. It was difficult to get metals to run sometimes, and, if any reliance could be placed on published data, it was not simply a question of viscosity.

"Alpax" and "Silumin."

MR. V. C. FAULKNER exhibited a casting* which had been sent to him for his opinion on it. It was a cylinder end. But he thought he would take advantage of Dr. Longmuir's presence in London, and ask for his opinion. Apparently the casting was sound until it had been machined. Underneath the upper surface as cast there was one large cavity, and, when a piece was torn off during machining it was found that the cavity extended all the way round. He presumed that when the liquid metal touched the top surface of the mould it immediately froze, and then, for some reason, it shrunk down, leaving the cavity, which had, of course, spoilt the casting. Dr. Longmuir gave the impression that Continental foundry methods were not in advance of British practice, but one thing that he (Mr. Faulkner) had been impressed with on the Continent, and which he had not seen in Great Britain, was that in an Italian works they had separate bins for containing the facing sand for every size of casting. Details had been given of experiments on the strength of nickel steels at the temperature of liquid air, and he had wondered what could be the practical application of this, when he was reminded that when he was associated with a crucible steel works his firm had actually had very serious complaints from Siberia that the picks and shovels had broken without any apparent reason. It was thus obvious that experiments dealing with strengths at low temperature had some practical bearing. Continuing, he said that there was a very interesting alloy which had been discussed extensively in Germany, France and the United States, but up to the present he had seen no British work on the subject. It was known in Germany as "Silumin" and in France as "Alpax." This alloy had the silicon-aluminium eutectic point composition 13 per cent. silicon. In France alkaline salts were added, but in America sodium was used. Silicon was lighter than aluminium, so that for any given volume of casting the weight was not very much, which was very important. The material, as cast, gave 12 tons per sq. in. This would allow them to reduce the weight of a motor lorry by 5 cwt. and to reduce the weight of a cycle car by about 150 lbs., which was appreciable.

* An illustration of this casting appears elsewhere in this issue under the heading of Foundry Queries.

Fluidity Considerations.

Dr. Hanson, in speaking of fluidity, had pointed out that perhaps it was some skin oxidation which affected fluidity. They had a very good example of that when they tried teeming chromium metal. When teeming chromium metal they could see what was termed the "crud" round the metal, and it was sluggish. But, reasoning in another direction, it was found well-killed steel when held for any length of time at the correct temperature in an electric furnace, lost its "life," and "life" was not a function of temperature. Here, apparently, there was small chance of surface oxidation.

Pouring Temperature and Physical Properties.

DR. S. W. SMITH, dealing with the tables showing the very striking differences in physical properties which had resulted from pouring at different temperatures, said it would have been interesting if the lecturer had indicated briefly some of the reasons to which those very striking differences were attributable. A case had occurred to him in connection with the 80:10:2 alloy which he believed had given a great deal of trouble during the war, although no very definite conclusions were come to. That was the 80:10:2 alloy. He was very much concerned with the evolution of gases, but the actual determinations of the gases did not really indicate that that was the reason for the extraordinary difficulty experienced in casting. He believed that two Americans had already determined the pouring temperature for that particular alloy, so that the actual practical difficulties were practically overcome.

Unstable Overheated Zinc May Cause Blowholes.

The explanation which had occurred to him to be a reasonable one in that case, although it did not apply, perhaps, in other cases, was that it was poured at a very high temperature; it was above the boiling point of zinc, and if such an alloy were agitated clouds of zinc vapour would come off. One could imagine that in the case of such an alloy cast at too high a temperature, where the zinc was in that unstable condition, the mere fact of pouring was sufficient to cause that agitation which resulted in the sudden escape of zinc. One ground for thinking that that was a possible explanation in the case of some alloys was that, if they examined the blowholes in such a casting, they were not blackened, but lined with a bright yellow surface; *i.e.*, just on a line with the blowhole they had an alloy richer in zinc than the rest. The hole had been filled with zinc vapour, which, during solidification, had condensed, causing a very thin layer of an alloy of zinc. There were many other things going on in other alloys which led to the extraordinary difficulties arising from casting at improper temperatures. He had been interested in Dr. Longmuir's reference to specific gravity. He was of opinion that more use should be made of density and specific gravity. Perhaps it was that we had no really rapid means of determining density; the method was tedious, but he believed that Dr. Shakespeare, at Birmingham University, had evolved a very useful form of density apparatus capable of giving the density of a sample weighing several pounds. A further application of that sort of thing would be of very great use in the pouring of castings, because the density of a casting was lower than the density of the metal. The method was to cut it up and pack it in a small quartz tube, and melt it, so that it ran down and practically filled a bulb at the bottom. The great point about it was that there was no adhesion between the molten metal and the quartz bulb. Where the metal was solid it was loose in the bulb, so that during solidification it was entirely free to contract in any way it liked.

THE AUTHOR'S REPLY

In his reply Dr. Longmuir said that with reference to the suggestion that diagrams of liquid contractions of the metals should be worked out, this problem was now in hand, but as yet nothing could be promised. Concerning Dr. Hanson's remark on the effect of casting temperature on crystallation, he said that, apart from the constitution of the structure, the crystals appeared more

interwoven when the metal was cast at the "correct" temperatures. Mr. Faulkner had not interpreted his remarks concerning Continental practice correctly. He (Dr. Longmuir) had been greatly impressed by what he saw there, especially before the war, the great activity of German research being a particular point of note. But when it came to the foundry floor, he did not think that British foundrymen had much to learn from his Continental *confrères*, and from his own observations he had come to the conclusion that the practical foundrymen in this country were ahead of those on the Continent, both in skill and technical knowledge. He agreed that the aluminium-silicon alloys, especially that of 13 per cent. silicon, were a most interesting series of alloys.

Finally, with respect to Dr. Smith's remarks on the subject of specific gravity, he said that this was a most important subject, and would amply repay close investigation.

Fluidity and Viscosity.

Mr. Lambert said that in his reply Dr. Longmuir had not mentioned fluidity. Fluidity was one of the characteristics of a molten metal about which foundrymen were particularly interested, because some metals appeared to be more fluid, and to run much freer than others. Temperature would appear to influence the fluidity of a metal, *i.e.*, the degree of superheat to which the metal was brought, and though it did not, apparently, influence the viscosity in the recognised sense in which the word was used, it certainly had a great influence on the running properties of the metal. Dr. Hanson was wondering what it was that determined the running properties of a molten metal. He (Mr. Lambert) believed that the degree of superheat in the metal had a great deal to do with it. One might almost regard a molten metal as being a super-saturated solution of potential crystals, and when a metal touched the mould, if the degree of superheat was too low, crystals were almost immediately formed. Those crystals had either to be re-dissolved in the metal, be pushed along, or something else had to happen. He had often witnessed castings when being run, and had seen crystals forming long before he should have expected their formation to occur, judged from the amount of superheat in the metal. He put it to Dr. Hanson that the degree of fluidity was determined, very largely, by the temperature conditions under which crystals are formed from molten metal when suddenly cooled.

On the motion of Dr. Hudson (Institute of Metals), seconded by Mr. J. Ellis (Institution of British Foundrymen), a hearty vote of thanks was accorded to Dr. Longmuir at the close of the proceedings.

Titanium.—In a serial (2,406) issued by the U.S. Bureau of Mines, Mr. R. J. Anderson (Metallurgist to the Bureau) states that titanium has found a large use recently in the making of sheet steel. About 2,500,000 tons of steel were treated with ferro-titanium alloys in the United States in 1918, and the metallurgical value of titanium additions has been proved to be of distinct importance in treating many kinds of steel. Titanium is used to a considerable extent in the States in the production of high-quality structural steels. The production of pure metallic titanium by the usual metallurgical reduction processes is exceedingly difficult, owing to the high melting point of the metal and its strong affinity for nitrogen, carbon and oxygen. The metal is produced commercially to-day by the reduction of titanium tetrachloride with sodium. At present there are four known ores of titanium, namely, rutile, ilmenite, titaniferous magnetites (and titanic iron ores), and certain complex monazite sands. The principal source of titanium for many years was rutile, but the known workable deposits of that mineral are few and widely scattered. They are confined to three localities in the United States, and one each in Canada, Europe and Australia. Ilmenite is the only one of many titanates which is important as an ore of titanium. Important deposits occur in the States, Scandinavia, Russia, Australia, and Africa, but the commercial production has so far been limited. The annual production of rutile concentrates in the States is about 200 short tons (2,000 lbs.). The production of ilmenite is variable; in 1918 it was 1,644 short tons, but in 1920 it had dropped to 268 tons.

A South Russian Steelworks.

The directors of the Belgian Société Providence Russe, in their report to the recent general meeting of the shareholders in Brussels, stated that they had no definite information concerning the situation of the Company's mines and works in Russia at the present time. A few months ago, however, they received a detailed report from an engineer (Mr. S. Eghiasaroff), who had remained for a certain time in the service of the management of the mines at Sartana, and who recently had returned to France. Making due allowance for the time elapsed since the report was written and for the political and economic position of the country, the directors believed they might state that the situation at their works and the mines was better than they might expect.

The report of the engineer in question, which is dated July 22, 1922, goes back to the end of 1919, when the Bolsheviks took possession of Mariupol on the withdrawal of General Denikin's troops. It gives details of the condition the offices, blast-furnace plant, coke ovens, steel plant, rolling mills, etc., were in at that date. A general idea of the position may be gathered from the engineer's conclusions. He states that if the resumption of work in Russia be not deferred too long, a large amount of work would have to be done to save the Providence Russe. The condition of the works, however, cannot be considered hopeless. In any case, all the machinery and gear will have to be thoroughly overhauled and repaired before operations can be restarted. Taking into consideration the situation and the needs of Russia, the most rational programme for the resumption of work as soon as a possibility presents itself would be to start two coke ovens and one blast furnace for the production of foundry pig, of which there is a great need, and next start a second blast furnace. The two furnaces would work on basic Bessemer pig-iron, and from time to time one would be changed over to produce open-hearth pig-iron. The next step would be to produce some extra mild basic Bessemer steel suitable for rolling light sections, while the remainder of the steel output could be used for rolling heavy sections and rails. This programme seemed the best for satisfying the immediate requirements of the market.

Compression Tests of Angle Bars.—Technological Paper No. 218, issued by the U.S. Bureau of Standards, presents the results of compression tests of 170 structural angles, made at Pittsburgh. The object of the tests was to determine the ultimate compressive strength of angles fastened at the ends in such ways as would closely correspond to their connections in transmission towers. There was also tested a series of angles with square ends. An end fixation factor was found to represent satisfactorily the effect of different types of end connections. The values of the maximum unit load in these tests vary over a considerable range for any given slenderness ratio and manner of fastening the angles in the testing machine. In most cases the specimen which sustained the greatest unit load for a given slenderness ratio and method of fastening suffered the least lateral deflection and the angle which bent most sustained the lowest unit load at failure, the deflection being measured at 4/9 of the theoretical maximum load. For large slenderness ratios the average values are well represented by Euler's formula for long columns, calculated for different values of the end fixation factor. The Kármán curves, recalculated for a yield point of 37,000 lbs. and modulus of elasticity of 30,000,000 lbs. per sq. in. represent the average results for small slenderness ratios for several methods of end fixation, except in the neighbourhood of l/r = 80 to 85, where the effect of eccentricity was greatest. For angles with ends folded the column formulas considered do not represent the results found in this series of tests. It is believed that the values of end fixation factor are of importance in the design of structures where the end conditions approximate those used in these tests, no matter what formula the designer prefers to use. Eccentricity of loading produces a diminution of column strength. In these tests the greatest effect of eccentricity was observed in the neighbourhood of a "free length" corresponding to l/r = 85, which agrees with the results of Kármán's investigations.

Trade Talk.

VICKERS, LIMITED, have purchased a part of the capital of the Reshitza Company.

M. SPITZER has removed his offices to 16 and 17, Devonshire Square, Bishopsgate, London, E.C.2.

THE IMPORTS of foreign iron ore at the Senhouse Dock at Maryport last week amounted to 3,170 tons.

HEAVY DAMAGE was done by a fire recently at the works of Messrs. C. M. Powell Bros., Aston Road, Birmingham.

MR. E. W. ANDERSON, on December 16, read a paper before the Wednesbury (Staffs.) Engineering Society, on hydraulic rams.

BEFORE the members of the Institution of Mechanical Engineers, Mr. Gascoigne Lumley, of Newcastle-on-Tyne, read a paper on "Reclamation Plant and its Operation."

ON December 22, at the Town Hall, Leamington, the employés of Sidney Flavel & Company, Limited, stove grate manufacturers, Eagle Foundry, Leamington, were entertained by Mr. Percival W. Flavel, J.P., the managing director.

BLYTH & PAWSEY, LIMITED, E. J. Smith & Company, Mansill Booth & Company, Limited, T. C. Endstone & Company (Successors), Limited, Richard Sizer, Limited, Brown & Green, Limited, and Fleming & Ferguson, Limited, have joined the Federation of British Industries.

O. T. LEMPRIERE & COMPANY, ore and metal merchants, of Melbourne, have established a branch at 1, Queen Victoria Street, London, E.C.4. Mr. S. Howell Thomas, who has managed the metal department of Copley's Bank for the past three years, has rejoined the company as European manager.

THE WELSH METAL EXTRACTION WORKS at Llanelly were offered for sale recently. The works, with sidings, etc., cover over three acres. The property is held on lease for a term of 60 years from March, 1919, at a ground rent of £100 per annum. The auctioneer announced that he had received a wire from Mr. Arthur John instructing him to withdraw the property, as there was every hope of reconstruction.

THE EDINBURGH CORPORATION'S TRAMWAY COMMITTEE have decided to recommend that a contract for 2,500 tons of tram rails be given to the Compagnie Anglo-Belge d'Importation et Export, Brussels. The tender of the Belgian firm amounts to £19,375. The minority voted in favour of giving the contract to the firm of Alex. M'Bean & Son, for the North Eastern Steel Company, Limited. This latter firm's quotation was £24,375, or a difference of about £5,000.

ARTHUR LEPLASTRIER & COMPANY PROPRIETARY, LIMITED, of Melbourne, have opened an office at 1, Queen Victoria Street, London, E.C.4. The company is an amalgamation of the businesses of Arthur Leplastrier & Company, which was established about 20 years ago, and the machinery department of O. T. Lempriere & Company. Mr. S. Howell Thomas has been appointed European manager. The company act as Australian agents for various firms of machinery manufacturers.

THE GENERAL REFRACTORIES COMPANY, LIMITED, of Sheffield, have taken over and are now working the Great Masson Fluor-Spar Mines at Matlock, Derbyshire, probably the largest fluor-spar mine in the county. Whilst said to contain inexhaustible supplies of fluor-spar of high quality, the mines have never been yet worked by modern methods, and arrangements are being made to equip them with steam winding gear, washing, screening and grinding plants, and an aerial ropeway.

SMITH'S DOCK COMPANY, LIMITED, have commenced an important scheme for enlarging their Bull Ring docks department at North Shields. Three acres are to be added to the yard area, two graving docks reconstructed, the river frontage straightened, a large reinforced encircling wall built, and new workshops and central offices erected. A scheme at the firm's South Bank yard on the Tees, which included the addition of 17 acres of land, construction of new docks, laying down of new shipbuilding berths, and erection of a large wharf and new workshops, etc., is nearing completion.

THE DIRECTORS of Redpath, Brown & Company, Limited, announce that with reference to the circular issued to the ordinary shareholders on June 8, 1922, it is intimated that the details necessary to enable the arrangement with Bolckow, Vaughan & Company, Limited, to be submitted to the shareholders have not yet been completely adjusted, and in consequence the directors have resolved to postpone the annual meeting of the company. The adjustment of these details is well advanced, and the directors hope that they may be able to hold the annual meeting and submit the arrangement during the month of February.

WITH REFERENCE to the suggestion in the House of Commons, by Mr. T. G. Duffy, M.P. for the Whitehaven Division, Cumberland, advocating that British iron be used in the construction of the hulls and fittings of the two new battleships, Mr. Duffy has received a reply from the Rt. Hon. Leopold C. M. S. Amery, M.P., First Lord of the Admiralty, stating that, after careful inquiries, it was found to be impracticable to restrict the steel makers to the extent suggested, but that he, the First Lord, was arranging that the contractors for the new ships be informed that the question of using British ores for the manufacture of the steel required had been brought to the notice of the Admiralty, and that, where such ores were considered suitable by the steel makers, such use would be appreciated.

THE REPORT of the Metals Extraction Corporation, Limited, states that provisional terms have been arranged with a firm of English engineers for the erection of process works in Norway upon a site with harnessed water-power sufficient for 100-ton per day plant. One of the largest zinc distilling firms in Belgium have decided to erect a 20-ton a day plant without delay. Proposals of British Metals Extraction Company for establishing large works in Great Britain have been under negotiation for some time, but decisions have been delayed owing to the depressed condition of trade and finance. The anticipated trade revival is likely to bring these negotiations to an early satisfactory issue. The company have secured an interest in large deposits of low-grade complex ores in England and Scotland to supply the proposed works for many years.

THE COUNCIL of the Society of Engineers (Inc.) have awarded the following premiums for papers read or published during 1922:—President's gold medal to Dr. C. V. Drysdale for his papers on "The Testing of Small Electrical Plant"; Bessemer premium (value £5 5s.) to Mr. E. E. Turner for his paper on "The Atlantic Cruise of H.M. Airsh. R34"; Nursey premium (value £3 3s.) to Dr. Herbert Chatley for his paper on "The Physical Properties of Clay-Mud"; Society premiums (value £3 3s.) to Mr. A. S. E. Ackermann for his paper on "The Physical Properties of Clay" (fourth paper), Mr. C. H. J. Clayton for his paper on "The Economics of Arterial Land Drainage," and Mr. W. Dinwoodie for his paper on "Wave Power Transmission"; Clarke premium (value £5 5s.) to Mr. R. C. Hill (Gloucestershire Engineering Society) for his paper on "The Submersible Pump"; Geen premium (value £5 5s.) to Mr. A. G. Short for his paper on "Heating."

Publications Received.

MR. H. A. J. RANG, 2, St. Nicholas Buildings, Newcastle-upon-Tyne. A wall almanack.

THE PICKERING SAND COMPANY, LIMITED, County Sand Quarries, Pickering, Yorkshire. "Moulding Sands: The Modern Need." This interesting booklet contains more than platitudes and claims. Interesting reports on Pickering sands are given by Prof. Boswell, Mr. C. A. King, M.Sc., and Messrs. Beecroft & Partners.

THE GENERAL ELECTRIC COMPANY, Schenectady, New York. A series of brochures bearing the following titles:—"Electric Melting Furnaces"; "Electricity in Iron Foundries"; "Electricity in the Iron and Steel Industry"; "Motor Drive for Metal Working Machinery"; "Electrically-Heated Ovens." The whole series are well produced, and contain useful suggestions for foundrymen.

MESSRS. CROSSLEY BROTHERS, LIMITED, Openshaw, Manchester. A reprint from "The Engineer" entitled "Wood Fuel Suction Gas Power Plant at the Lonely Mine, Southern Rhodesia." A brochure, "Dearer Coal and Cheaper Power," which sets out the economies resulting from the utilisation of gas instead of steam as motive power in works. This catalogue is of distinct interest for most foundrymen. "Free Fuel Power" is the title of a third brochure devoted to the production of gas from sawdust and similar materials.

MR. A. AITCHISON, engineer at the blast-furnaces and steelworks of Palmers Shipbuilding and Iron Company, Limited, for 33 years, who has retired, has been the recipient of a presentation from the officials and men.

XUM

IRON AND STEEL MARKETS.

Pig-iron.

With the return of more active conditions in the opening markets of the New Year, it is, at all events, satisfactory to record a much more confident tone, and while still retaining a trace of the holiday spirit, business in pig-iron is again settling down on steady lines towards an all-round and progressive expansion. Even in the far North, where Scottish smelters have hitherto experienced a quiet time, as compared with their southern competitors, there has been a distinct broadening of inquiry, which is expected, when the New Year celebrations are concluded to develop in satisfactory volume of new business. In Glasgow there is a distinct improvement apparent in the market, and some good lines of Scotch iron have been sold for the South, but local consumers seem slow in coming forward as actual buyers. No doubt, however, there will be a change to report in this respect ere long. On the export side, there has also been an improvement, and about 2,000 tons have been recently sold for America besides some lines for the Australian market. In fact, the demand from abroad shows an improvement all round. In Lancashire, the position in the foundry iron market is better than it was, simply because the iron-founders in the district are better supplied with work; but any expectation of higher prices for No. 3 ordinary iron may easily be disappointed. One reason for this is the return, as competitors in the Manchester market, of the North Lincolnshire group of furnaces. These furnaces have been out of blast ever since the great coal strike of 1921, or, in other words, for more than a year and a-half. The renewed competition of Lincolnshire foundry iron will therefore tend to check any attempt to raise the price of common iron in Manchester. Better inquiries and a larger market for pig-iron were the conditions reported at Birmingham, and also that some firms have closed their books for the time being, which is a sure indication that higher prices are expected in the near future. It looks as though, for the moment, demand is in excess of supplies, and it is now a question how long it will be before additional furnaces are blown in. As to this, the difficulty is the scarcity and accompanying dearness of coke. The quotations now ruling are from 22s. to 23s., which is abnormally high, and makes pig-iron an unprofitable proposition at the prices now obtainable; but supplies of coke are so restricted that it is doubtful whether any considerable number of additional furnaces could be blown in with safety. On the North-East Coast trade has been practically suspended during the past fortnight, and little serious business may be expected until the termination of the New Year holiday. There are, however, indications of a real revival of interest in the home trade, and business with Scotland is certainly better. Consumers are getting busier, and the amount of forward buying put through shows they are convinced that there is little, if anything, to be gained by waiting. Rising fuel costs are an obstacle to lower pig-iron values, but the extraordinary demand for coke from abroad, coupled with the increasing consumption at home, would appear to show that fuel will for some little time ahead continue to be a dominant factor. Hence there would seem to be but little hope of lower pig-iron quotations in the early future, and in this connection the advance in American pig-iron is not to be ignored. Export business continues very moderate and spasmodic owing to the exchange difficulties. At Middlesbrough there are now thirty-seven blast furnaces in operation, compared with twenty at the beginning of 1922. Current quotations rule as follow: No. 1 and silicious, 95s.; No. 3 G.M.B., 91s.; No. 4 foundry, 85s.; No. 4 forge, 82s. 6d.

There has been nothing doing in hematite pig-iron over the holidays, but makers are satisfactorily situated, most works being pretty fully sold till the end of January, with good bookings also over the rest of the first quarter of 1923. Prices look like being firmly held and are unchanged at the previous week's levels. East Coast mixed numbers stand at 93s. to 93s. 6d., with No. 1 at a premium of 6d. per ton.

Finished Iron.

The outlook in the manufacturing departments of the iron trade is certainly more encouraging than has been the experience of some two years past, makers' order books carrying a better tonnage of specifications than might have been anticipated in the prevailing conditions recently reported. This welcome change from the previous depression is probably attributable in part to the stimulated demand for shipbuilding materials, while the exhaustion of stocks in merchants' warehouses is also a contributory factor, many members of the trade having unquestionably withheld orders in the expectation of securing lower prices by pursuing a waiting policy. There is also a better demand for sheet iron for the motor industry, and by nut and bolt makers. These circumstances, coupled with the fact that the mills in operation have a better supply of contracts on their books than they have had recently, has given the bar iron industry a more buoyant tone, and manufacturers are looking forward to more full and regular employment and more profitable prices. It is the general feeling that as demand improves prices must go up, those at present quoted being most unprofitable. It is, however, more than probable that at the forthcoming quarterly meeting at Birmingham some definite movement in finished iron prices may eventuate, but it can hardly be anticipated that in this early stage of a general trade revival any very drastic changes will be made, or indeed would be regarded as politic by the majority of manufacturers.

Steel.

The improvement in the steel industry recently reported is well maintained in most departments, the anticipated demand for railway material having opened out. Large contracts are being placed by the British companies, and there is little doubt that a substantial portion of the second instalment of £30,000,000 due to the companies for "deferred maintenance" will be spent in this way. Contracts already placed cover a wide field. At Sheffield, the railway steel branch of the city's great industry, which for two years past has been among the slackest section of the trade, is now growing progressively active. From Middlesbrough large orders are reported for steel rails and constructional material. Large railway contracts for India, involving at least 3,000 wagons, have also been placed in Birmingham and the Black Country. Important Dominion orders are coming forward. The outlook in semi-products continues to improve, makers of basic billets in the Sheffield district being very busy, and the call for acid steel is much better, though it does not amount to anything very great at present. Nevertheless, manufacturers are confident of the future. Soft basic billets are now quoted at £7 15s., and even at that figure users find some difficulty in making contracts. The recent firmness in tinplates is maintained, and the general run of quotations for the standard box is 3d. above the minimum, viz., 20s. 3d. Some of the tinplate makers who are not associated with the steelworks do not appear to be quite so satisfied with the scheme as they were, and there is a possibility of the arrangement not being renewed at the end of the temporarily fixed period.

Scrap.

The activity recently reported in the demand for heavy steel scrap at Sheffield and in South Wales has now extended to most other markets, and in Scotland merchants, as a rule, have practically no stocks to dispose of, and unless they can obtain a fair premium on current values are not prepared to do business. In common with all other consuming areas, there is a marked feeling of optimism in the trade and higher prices, and what is much more important, considerably increased demand for all classes of scrap is confidently looked for. Prospects are certainly very much brighter than was the case twelve months ago, and both buyer and seller should be able to look forward to brighter times. A number of the Scottish foundries are endeavouring to secure their supplies of cast-iron scrap over the first two or three months of the year. Owing to the number of buyers in the market, however, sellers are averse to committing themselves for any time ahead, and will, as a rule, only sell for early January delivery. At Middlesbrough conditions are somewhat similar to those reported above with prices nominally unchanged as follows, all quotations being delivered works:—Heavy steel scrap, 68s. 6d. to 70s.; cast-iron scrap, machinery quality, 76s.; heavy steel turnings and cast-iron borings, 55s. to 57s. 6d.; heavy wrought-iron piling scrap, 72s. 6d.; good heavy special forge, 80s. to 85s. per ton.

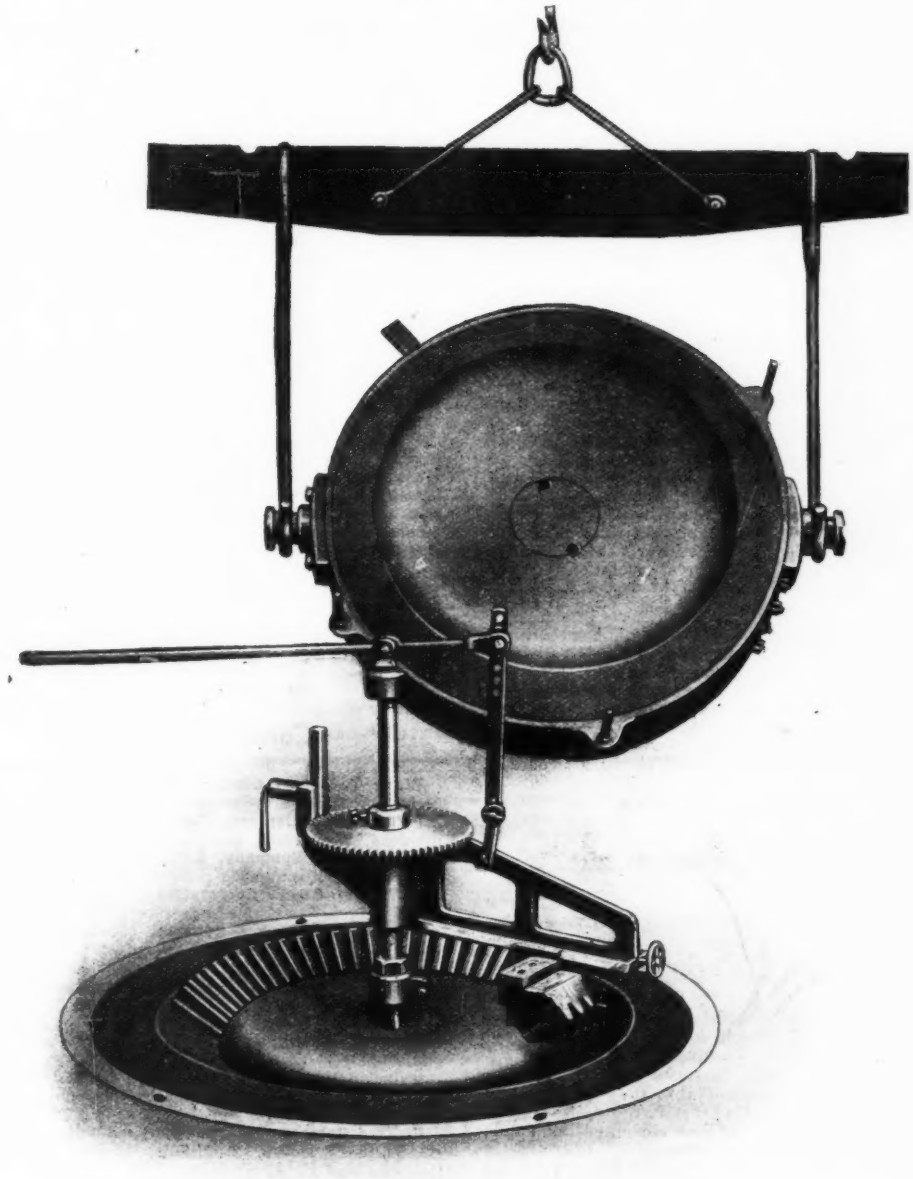
Metals.

Copper.—The steady recovery in base metals noted of late has been maintained, the market for standard copper at the reopening after the holidays showing a firm tendency, with every prospect of improvement as the year advances. Advices from America in regard to domestic consumption are optimistic, and some evidence has been forthcoming that a certain scarcity of prompt metal exists. On this side the failure of sterling entirely to maintain the whole of the recent

Continued on page 22.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,

(MANCHESTER), LIMITED.

BLACKFRIARS, MANCHESTER.

IRON AND STEEL MARKETS.—*Continued.*

appreciation, combined with speculative orders and bullish sentiment, has strengthened the value of standard. The rise in standard, however, has not kept pace with the rise in electro, and the margin between the two has widened once more. Current quotations: *Cash*: Wednesday, £64 12s. 6d.; Thursday, £64 10s.; Friday, £64 10s.; Tuesday, £64 12s. 6d. *Three months*: Wednesday, £65 7s. 6d.; Thursday, £65 10s.; Friday, £65 10s.; Tuesday, £65 7s. 6d.

Tin.—The tendency of the market for standard tin continues irregular, and although fluctuations in values have taken only a narrow range, the general conditions are more unsettled than has been the case of late, due probably to holiday influences. America has been buying on an improved scale, but the demand from home consumers remains at a low level. The Straits have sold rather freely, following the course of the London standard market, and sales are also reported from Batavia. Chinese is still being freely offered, though mostly by dealers who have full quantities afloat to Europe and America. Current quotations:—*Cash*: Wednesday, £182 2s. 6d.; Thursday, £182 2s. 6d.; Friday, £182 2s. 6d.; Tuesday, £182 5s. *Three months*: Wednesday, £183 10s.; Thursday, £183 12s. 6d.; Friday, £183 12s. 6d.; Tuesday, £183 15s.

Spelter.—The market for this metal has evidenced a somewhat quieter turn during the past week, home consumption for obvious reasons having been on a lower scale. Near deliveries continue scarce, and the future position is viewed with uncertainty. On the one hand, American advices are bullish, and with Europe mainly dependent on that country for its chief supplies, we may see an advance in the new year. On the other hand, Belgian production is increasing very slowly, and Germany is still in need of an outside source of supply. Current quotations:—*Ordinary*: Wednesday, £37 7s. 6d.; Thursday, £37 12s. 6d.; Friday, £37 10s.; Tuesday, £37 10s.

Lead.—The market for soft foreign pig has continued quietly steady, with a fair home demand. Reports from America state that consumers over there who are not fully covered for the next month or two are finding it difficult to make engagements now for any large amount. Current quotations:—*Soft foreign*: (*prompt*): Wednesday, £26 7s. 6d.; Thursday, £26s. 7s. 6d.; Friday, £26 7s. 6d.; Tuesday, £26 17s. 6d.

Gazette.

DOHERTY (PHILIP S.) (ENGINEERS), LIMITED.—It has been resolved that the company be wound up voluntarily. Mr. E. Woodroffe, 9, Pancras Lane, E.C., I.A., has been appointed liquidator.

MESSRS. R. HOUGH and R. Hough, boiler makers. Newtown Boiler Works, Newtown, Wigan, trading under the style of Hough & Sons, have dissolved partnership, so far as concerns Mr. R. Hough.

FOUNDRY AND MACHINE COMPANY, LIMITED, London, W.C.—It has been resolved that the company be wound up voluntarily. Mr. W. H. Brown, 19a, Coleman Street, E.C., C.A., has been appointed liquidator.

ELECTRO-METALLURGICAL EXTRACTION, LIMITED.—It has been resolved that the company be wound up voluntarily. Mr. J. A. Charlton, Bank of England Chambers, Manchester, I.A., has been appointed liquidator.

THE partnership heretofore subsisting between Messrs. J. Moore and P. Heywood, carrying on business as ironfounders at 60, Reservoir Street, Bolton, under the style of Moore & Heywood, has been dissolved.

MESSRS. A. MCKINLAY KISSACK, A. Yates and A. H. G. Mowatt, electrical and mechanical engineers, 179, Great Howard Street, Liverpool, trading under the style of Kissack & Yates, have dissolved partnership.

ANGLO-BALTIC SHIPBUILDING AND ENGINEERING COMPANY, LIMITED.—A winding-up petition has been presented by S. Instone & Company, Limited, 52, Leadenhall Street, E.C. Hearing, Royal Courts of Justice, Strand, January 16. Messrs. B. A. Woolf & Company, 37, Walbrook, E.C., solicitors.

MR. H. A. BUTT has been appointed to supervise the construction of the new Southampton floating dock by Sir W. G. Armstrong, Whitworth & Company, Limited.

Personal.

MR. F. BEST, one of the directors and secretary of Thomas Firth & Sons, Limited, has been the recipient of a presentation from the officials and men on the occasion of his leaving Sheffield to take up the position of commercial manager of Bolckow, Vaughan & Company, Limited.

MR. M. DENNY, vice-chairman, has been elected chairman of William Denny & Brothers, Limited, Leven Shipyard, Dumbarton, in succession to Colonel J. M. Denny, deceased. Mr. J. M. Denny, Barnhill, becomes vice-chairman: Mr. Walter Brock is retiring from the board, and Mr. Leslie Denny is rejoining the board.

Deaths.

MR. R. W. DAVIES, whose death has occurred at Darlington at the age of 64, was well known in the iron and steel industry in the North-East. He went to Darlington 22 years ago as managing director for Sir Theodore Fry & Company, Limited, Rise Carr Rolling Mills, and was at the time of his death a director of the same works, of which Bolckow, Vaughan & Company, Limited, some time ago assumed control. He had been a Justice of the Peace for Darlington borough since 1906.

MR. GEORGE ADDY, of Sheffield, died recently at the age of 65 years. Born on April 15, 1857, Mr. George Addy was educated at Leeds and Blackpool. He went to Sheffield in the early 'nineties, and established a business as a consulting engineer, to which that of steel manufacturer was afterwards added. He became a member of the Institution of Mechanical Engineers in 1890, and a paper on "Milling Cutters," which he read in that year, was accepted as a standard work. He devoted much attention to labour-saving appliances, and made a speciality of the heavy machine tools used by shipbuilders, locomotive engineers and boiler makers. He was the sole proprietor of Golightly's Patent Rail Crossing Lift.

Company News.

W. & T. Avery, Limited.—Interim dividend, 5 per cent., less tax, on ordinary.

Falkirk Iron Company, Limited.—Interim ordinary dividend, 5 per cent., less tax.

Crompton & Company, Limited.—Interim dividend, 7 per cent per annum on preference.

Dominion Steel Corporation, Limited.—Dividend No. 44, 1½ per cent. on preference shares.

Abram Brooksbank & Company (Sheffield), Limited.—Capital £7,500 in £1 shares.—Steel manufacturers.

T. H. Rhodes, Limited.—Capital £10,000. Ironware manufacturers, etc. Directors: H. C. Rhodes and B. Dunn.

Thos. W. Ward, Limited.—Quarterly dividends, 5 per cent. per annum on first and second preference and employés' shares.

Irvine's Shipbuilding and Dry Docks Company, Limited.—Half-year's dividend on preference, 8 per cent. per annum, less tax.

F. T. Robinson & Company, Limited.—Capital £2,500 in £1 shares. Engineers. Directors: F. T. Robinson and E. A. Sheldon.

Henry Rossell & Company, Limited.—Payment of half-yearly dividend on 5½ per cent., free of tax, cumulative preference shares postponed.

Columbus Machinery, Limited, Caxton House, Tothill Street, London, S.W.1.—Capital £3,000 in £1 shares. Directors: J. Rolland & C. S. G. Walker.

John Spencer & Sons, Limited.—Credit balance, including amount brought forward, £30,738; renewals and improvements extension, £15,000; carry forward, £15,738.

Metal Preserving Company, Limited, 10, Victoria Street, Liverpool.—Capital £3,000 in £1 shares. Directors: J. L. Bennett, F. A. Derry, R. Turner and E. Hardisty.

Bull's Metal and Melloid Company, Limited.—Transferred from reserve, £7,500; transferred from dividend equalisation account, £3,000; dividend for year, 10 per cent., free of tax; carry forward, £1,402.

Argentine Iron and Steel Company, Limited.—Loss on trading, £191,856; after providing for general depreciation, debenture interest, etc., net loss, after taking in £70,782 standing to credit of contingencies reserve, £250,923.

Bell & Company (Cardiff), Limited, Asbestos House, Burt Place, Cardiff.—Capital £10,000 in £1 shares (5,000 6 per cent. preference and 5,000 ordinary). Dealers in asbestos, engineers, mill furnishers, etc. Permanent managing director: C. H. Stallybrass.

Telephone: 21, Penistone. Telegrams: "Durrans, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Write for illustrated catalogue on Blacking and Foundry Requisites, also for our latest Price List.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS, FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

CASTINGS for Engineers, Motor Trades, &c.,

Castings Sand-Blasted.

"STAR FOUNDRY"
Birmingham Street, WILLENHALL, STAFFS.

Telephone: No. 25, WILLENHALL.
Telegrams: "STAR FOUNDRY, WILLENHALL."

WILLIAM HARPER, SON & CO.,

Malleable and Soft Grey Ironfounders.

Mr. Pattern Maker— one moment please!

YOUR part is the making of **Engineers' Patterns.**
YOU know your work—that's why you succeed.
WHERE we help you is in the making of dependable Varnishes.
PATTERN VARNISH is a special line with us. We have been noted makers for years.

Samples and quotations at your disposal.

W. PICKARD & Co., Ltd.
Rutland Road, Sheffield.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	64	12	6
Three months	65	7	6
Electrolytic	71	15	0
Tough	68	0	0
Best selected	68	0	0
Sheets	96	0	0
India	82	10	0
Wire bars, Jan.	71	15	0
Do. Feb.	71	15	0
Do. Mch.	71	15	0
Ingot bars	71	15	0
H.C. wire rods	75	10	0
Off. aver. cash, Nov. 62	17	0	6/11
Do. 3 mths., Nov. 63	14	3	9/11
Do. Settlement Nov. 62	17	1	10/11
Do. Electro, Nov. 70	9	3	5/11
Do. B.S., Nov.	66	8	9
Aver. spot price, copper, Nov.	62	16	1¾
Do. Electro, Nov.	70	14	3½

Solid drawn tubes	13½d.
Brazed tubes	13½d.
Wire	10½d.
Yellow metal rods	6½d.
Do. 4x4 Squares	8½d.
Do. 4x3 Sheets	9½d

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d
Rods, drawn	10½d.
Rods, extruded or rolled	6½d.
Sheets to 10 w.g.	10d.
Wire	9½d.
Rolled metal	9½d.

TIN.

	£	s.	d.
Standard cash	182	5	0
Three Months	183	15	0
English	182	5	0
Bars	184	5	0
Chinese	179	15	0
Straits	183	10	0
Australian	183	5	0
Eastern	183	5	0
Banca	182	12	6
Off. aver., cash, Nov.	179	8	9 1/3
Do. 3 mths., Nov.	180	3	5 12/20
Do. Settlment Nov.	179	8	7 7/11
Aver. spot, Nov.	179	7	3½

SPELTER.

	£	s.	d.
Ordinary	37	10	0
Remelted	35	0	0
Hard	28	0	0
Electro 99.9	43	0	0
English	38	0	0
India	29	0	0
Prime Western	38	0	0
Zinc dust	49	0	0
Zinc ashes	11	0	0
Off. aver., Nov.	36	18	9
Aver., spot, Nov.	38	0	2¾

LEAD.

	£	s.	d.
Soft foreign ppt	26	17	6
English	28	0	0
Off. average, Nov.	25	12	2 13/20
Average spot, Nov.	26	3	5½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	43	0	0
Do. V.M. ex. whf.	43	0	0
Dutch	43	0	0
Rods	50	0	0
Boiler plates	41	0	0
Battery plates	43	0	0

ANTIMONY.

	£	s.	d.
English regulus	27	0	0
Special brands	33	10	0
Chinese	24	10	0
Crude	17	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	11	12	6

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
45/50%	11	17	6
75%	20	10	0

Ferro-vanadium—
35/40% 17/- lb. va.

Ferro-molybdenum—
70/75% c. free 9/3 lb. mo.

Ferro-titanium—
23/25%, carbonless 1/1½ lb.

Ferro-phosphorus, 20/23%, £24

Ferro-tungsten—
80/85%, carbon free 1/5 lb.

Tungsten metal powder—
98/99% 1/11 lb.

Ferro-chrome—	£	s.	d.
4/6% car.	22	10	
6/8% car.	21	15	
8/10% car.	21	5	

Ferro-chrome—	£	s.	d.
Max. 2% car.	54	0	
Max. 1% car.	65	0	
Max. 0.70% car.	73	0	
67/70%, carbonless	1/7 lb.		

Nickel—99%, cubes or pellets £130

Cobalt metal—98/99% 11/9 lb.

Aluminium—98/99% £95

Metallic Chromium—
96/98% 4/6 lb.

Ferro-manganese(net)—	£	s.	d.
76/80%, loose	15		
76/80%, packed	16		
76/80%, export	14		

Metallic manganese—
94/96%, carbonless 2/3 lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s.	d.
	2	6
Finished bars, 18% tungsten	3	0

Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ⅛ in. to ½ in. by ½ in., and all sizes over four times in width over thickness 3d. lb.
Bevels of approved sizes and sections 6d. lb.
If in coils 3d. lb.
Packing £3 ton.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces 3d.
Turnings and swarf 1d.
Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy Steel	4	0	0	4	10	0
Bundled steel & shearings	3	7	6	4	0	0
Mixed iron & steel	3	10	0	3	17	6
Heavy cast iron	3	15	0	3	17	6
Good machinery for foundries	3	15	0	4	5	0

Cleveland—	£	s.	d.
Heavy steel	3	8	6
Steel turnings	2	16	0
Cast-iron borings	2	16	0
Heavy forge	4	2	6
Bushelled scrap	3	12	6
Cast-iron scrap	3	16	0

Lancashire—	£	s.	d.
Cast iron scrap	4	2	6
Heavy wrought	3	11	3
Steel turnings	2	10	0

London—	£	s.	d.
Copper (clean)	37	0	0
Brass (clean)	32	0	0
Lead (less usual draft)	23	0	0
Tea lead	20	0	0
Zinc	22	10	0
New aluminium cuttings	64	0	0
Braziery copper	48	0	0
Gun metal	44	0	0
Hollow pewter	150	0	0
Shaped black pewter	90	0	0

Above are merchant's buying prices delivered yard.

PIG-IRON.

N. E. Coast—	
Foundry No. 1	95/-
Foundry No. 3	91/-
Forge No. 4	82/6
Mottled	80/-
Hematite No. 1	93/9
Hematite M/Nos.	93/-
Midlands—	
Staffs. common	—
„ part-mine forge	—
„ „ foundry	—
„ Cold blast, ord.	190/-
„ „ roll iron	200/-
„ basic	—
Northants forge	70/- to 72/6
„ foundry No. 3	77/6 „ 80/-
„ basic	80/-
Derbyshire forge	75/-
„ foundry No. 3	82/6
„ basic	80/-
Scotland—	
Foundry No. 1	99/6
„ No. 3	94/6
Hematite M/Nos.	105/-
Sheffield (d/d district)—	
Derby forge	85/6
„ foundry No. 3	87/6
Lincs. forge	86/6
„ foundry No. 3	90/-
„ basic	86/6
E.C. hematite	104/2
W.C. hematite	105/-
All d/d in the district.	
Lancashire (d/d eq. Man.)	—
Derby forge	—
„ foundry No. 3	90/-
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	—
„ foundry No. 3	—
Summerlee foundry	109/6
Glengarnock foundry	111/6
Gartsherrie foundry	111/6
Monkland foundry	109/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (cr.)	£10 10 to 11	10	0
Angles	£10 15 to 11	15	0
Tees to 3 united ins.	£11 to £12		
Nut and bolt	9	12	6
Hoops	14	0	0
Marked bars (Staffs.)	13	10	0
Gas strip	£10 10 to 10	15	0
Bolts and nuts, ⅜ in. × 4 in.	16	10	0

Steel—	£	s.	d.
Ship plates	£9 to 9	10	0
Boiler plates	12	10	0
Chequer plates	10	5	0
Angles	£8 12 6 to 9	0	0
Tees	£9 12 6 to 10	0	0
Channels	8	10	0
Joists	9	0	0
Rounds & squares 3-in. to 5¼in.	9	10	0
Rounds, under 3in. to ⅜in.	9	0	0
Flats, over 5in. wide and up	9	15	0
Flats 5in. to 1¼in.	9	0	0

	£	s.	d.
Rails, heavy	8	15	0
Fishplates	13	10	0
Hoops	11	0	0
Black sheets, 24 g.	11	15	0
Galv. cor. sheets, 24 g.	17	7	6
Galv. fencing wire, 8 g. plain	16	0	0
Rivets, ½ in. dia	11	15	0
Billets, soft	6 10 0 to 7	0	0
Billets, hard	7 0 0 to 8	0	0
Sheet bars	7	0	0
Tin bars	7	13	9

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 3
Sheet	1 3½
Wire	1 3½
Rods	1 2½
Tubes	1 6
Castings	1 1

Delivery 3 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.
CHARLES CLIFFORD & SON LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	11d. to 1/5
Rolled—	
To 9 in. wide	1/5 to 1/11
To 12 in. wide	1/5½ to 1/11½
To 15 in. wide	1/6 to 2/0
To 18 in. wide	1/6½ to 2/0½
To 21 in. wide	1/7½ to 2/1½
To 25 in. wide	1/8½ to 2/2½
Ingots for spoons and forks	11d. to 1/5
Ingots rolled to spoon size	1/2 to 1/8
Wire round—	
3/0 to 10. G.	1/8½ to 2/3½

with extras according to guage.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	28,76
No. 2 foundry Valley	25.00
No. 2 foundry, Birm.	23.00
Basic	26.21
Bessemer	29.27
Malleable	27.96
Grey forge	26.27
Ferro-manganese 80 % delivered	100.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y, at mill	43.00
Bess. billets	36.50
O.-h. billets	36.50
O.-h. sheet bars	36.50
Wire rods	45.00
	Cents.
Iron bars, Phila.	2.27
Steel bars	2.00
Tank plates	1.95
Beams, etc.	2.00
Skelp, grooved steel	2.00
Skelp, sheared steel	2.00
Steel hoops	2.75
Sheets, black, No. 28	3.35
Sheets, galv., No. 28	4.35
Sheets, blue an'l'd, 9&10	2.50
Wire nails	2.70
Plain wire	2.45
Barbed wire, galv.	3.35
Tinplate, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	35/-
„ furnace	25/-
Durham & North. fdy.	27/6 to 30/-
„ furnace	25/6
Other Districts, foundry	25/- to 30/-
„ furnace	24/-

SWEDISH IRON.

Bars, hammered basis sizes Basis price £22 to £23

	£ s. d.
Rolled Ordinary— Assortment ..	18 0 0 to 18 10 0
Nail Rods— Square, round and flats ..	

Keg Steel nom. £38 to £40
Faggot Steel nom. £30 to £32

Blooms—
Single welded .. £10 to £11

Billets—
Single and double welded £13 to £14

Pig-Iron—
Grey, white or mottled .. £7 to £7 10 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

	Up to and incl. 6 in.	
Gas	57½%	Tube prices are now free.
Water	52½%	
Steam	47½%	

TINPLATES.

I.C.Cokes,	20×14, box	20/3
„	28×20, „	41/–
„	20×10, „	29/6
„	18¾×14, „	21/–
I.X.	„	47/–
I.X.X.	„	53/–
F.C.B.Y.	21×13⅝ „	38/–
C.V.B.G.	16¾×15, „	36/–
I.C.W.	20×14, „	18/4½
„	28×20, „	36/10½
„	20×10, „	26/4½
„	18¾×14, „	18/10½
Terneplates,	28×20, „	36/9

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
Dec. 27	64	12	6	inc.	7/6
„ 28	64	10	0	dec.	2/6
„ 29	64	10	0	No change	
Jan. 1	—	—	—		
„ 2	64	12	6	inc.	2/6

Electrolytic Copper.

Dec. 27	71	15	0	inc.	2/6
„ 28	71	10	0	dec.	5/–
„ 29	71	15	0	inc.	5/–
Jan. 1	—	—	—		
„ 2	71	15	0	No change	

Standard Tin (cash).

Dec. 27	182	2	6	inc.	25/–
„ 28	182	2	6	No change	
„ 29	182	2	6	„	
Jan. 1	—	—	—	„	
„ 2	182	5	0	inc.	2/6

Tin (English ingots)

Dec. 27	182	0	0	inc.	20/–
Dec. 28	182	0	0	No change	
„ 29	182	0	0	„	
Jan. 1	—	—	—	„	
„ 2	182	5	0	inc.	5/–

Zinc Sheets (English).

Dec. 27	42	0	0	No change	
„ 28	42	0	0	„	
„ 29	43	0	0	inc.	20/–
Jan. 1	—	—	—		
„ 2	43	0	0	No change	

Spelter (ordinary).

Dec. 27	37	7	6	dec.	2/6
„ 28	37	12	6	inc.	5/–
„ 29	37	10	0	dec.	2/6
Jan. 1	—	—	—		
„ 2	37	10	0	No change	

Lead (English)

Dec. 27	27	10	0	No change	
„ 28	27	10	0	„	
„ 29	27	10	0	„	
Jan. 1	—	—	—		
„ 2	28	0	0	inc.	10/–

THE
ARMITAGE WORKS Co., Ltd.
Manufacturers of
Highly Refractory Bricks and Blocks
FOR ALL PURPOSES.

SPECIALITIES:
CUPOLA LININGS.
Ladle Bricks for Siemens Ladles.
Chequer Bricks, etc., for Siemens Furnaces.
Gas Producer Linings.

GROUND GANISTER
for Iron, Steel, and Brass Furnaces. Forced Draught Brass Furnaces. Semi-Silica or Semi-Ganister Bricks. Silica Cement.

DEEPCAR, Near Sheffield.

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Sunbrand (Cannon), London.

Telephone:—
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5959 Central.

BARS, HOOPS, SECTIONS & WIRE
in IRON, STEEL, COPPER and BRONZE.

Galvanised Telegraph, Telephone, Cable and Trolley Wire
To all Specifications.

Contractors to H.M. Government (Admiralty, G.P.O., India Office, War Office, Colonies), English and Foreign Railways, &c.

BEST H. C. COPPER & BRONZE WIRE a speciality.

Medals:—Sydney (Bronze) 1879, New Zealand (Gold) 1882, Liverpool (Silver) 1886, Adelaide (Gold) 1887, Franco-British Grand Prix (Highest Award) 1908.

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WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

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EXCHANGE BLDGS., PORT TALBOT
5, MURZBAN ROAD, BOMBAY.
1, LALL BAZAR CALCUTTA.

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LIMPET

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31, RAFFLES PLACE, SINGAPORE.
JAVA STREET, KUALA LUMPUR.
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COX'S BUILDINGS, KARACHI.

PIG IRON
SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.
IRON & STEEL SCRAP
COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM COLVIN & COMPANY,
ROYAL EXCHANGE, MIDDLESBROUGH.
93, HOPE STREET, GLASGOW.

SITUATIONS VACANT AND WANTED.

LATE PRODUCTION MANAGER of well-known firm desires position; experience in Engine and Ordnance Work, Colliery and General Engineering.—Apply, W. LAING, 4, Main Road, Handsworth, Sheffield.

THE Lancashire Branch of the Institution of British Foundrymen beg to announce that several members, who have had varied experience as Foremen, etc., are at present disengaged. Employers who are in need of Foremen or other members of their foundry staff are invited to communicate with the Honorary Secretary, T. MAKEMSON, 21, Beresford Road, Stretford, Manchester

SITUATION required as Steel Moulder; active, strong and healthy; age 50 years; 22 years in last situation, 10 years as under-foreman; shop doing approx. 50 to 80 tons per week; castings to 3 tons; general engineering and locomotive; able to take charge. Member of F.M.B.S.; no other society.—Box, 314, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Strand, London, W.C.2.

WANTED.—Assistant Manager for Steel Foundry, light and medium work; young and energetic, up-to-date knowledge of machine practice imperative; electric furnace practice an advantage but not essential.—State salary and experience, Box 320, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PARTNERSHIPS.

PARTNER-SHAREHOLDER

for manufacture of Seamless Tubes System Mannesmann (25 per cent. improved) wanted. The plans of the new machines will be eventually sold.—Letters to MR. JOSEF WILDNER, Slatinany 175 u Chrudimi Czechoslovakia.

AGENCIES.

THE Manufacturers of the most up-to-date Moulding Machines in the world, who have over 16,000 Machines at work in the various Countries of the Universe, desire well accredited and energetic Selling Agents in all British Colonies and Possessions for the sale of their Moulding Machines, and all Foundry Plant. In reply please write to THE UNIVERSAL SYSTEM OF MACHINE MOULDING & MACHINERY COMPANY, LIMITED, 97, Queen Victoria Street, London, E.C.4.

AUCTION SALE.

In the High Court of Justice, Chancery Division.

IN THE MATTER OF A. G. SCOTT & CO., LTD.,

with the approbation of Mr. Justice Eve, pursuant to the Order of September 13, 1922.

By Auction in the Estate Sale Room, 20, Hanover Square, W., on Monday, January the 22nd, 1923, at 2.30 p.m. precisely, by Mr. John F. Knight, of the firm of Messrs.

KNIGHT, FRANK & RUTLEY.

IN ONE LOT,

AS A GOING CONCERN,

The well-known and old-established

Business and Goodwill of Messrs. A. G. Scott & Co., Tin Box Manufacturers,

Including the Valuable Leasehold Waterside Factory Premises, known as Crown Wharf, Grove Street and Hanlon Street, Deptford, having a floor area of about 69,300 square feet, with excellent Offices, Concert Hall, Canteen, Central Yard, etc., also 12 to 26, Hanlon Street (even numbers), together with the important

MACHINERY.

PLANT, STOCK,

Dies, Tools, Trade Fixtures, Furniture, Tinplates, partly manufactured, unused and unfinished Stock, Solder, Varnish, Glue, Ink, Paint, etc., with the right to use the firm's name and processes.

Inspection of the Works and Materials by appointment with the Auctioneers. Particulars, Plans and Conditions of Sale may be had of the Solicitors:—

Conditions of Sale may be had of the Solicitors:—King's Bench Walk, Temple, E.C.4;

Messrs. Bircham & Company, 50, Old Broad Street, E.C.2;

Messrs. Parker, Garrett & Company, St. Michael's Rectory, Cornhill, E.C.3;

or of the Auctioneers, at their offices, 20, Hanover Square, W.1; 90, Princes Street, Edinburgh; 78, Vincent Street, Glasgow; and 41, Bank Street, Ashford, Kent.

MACHINERY.

TWO Cross Compound Horizontal Drop Valve Engines, 12½ in. and 20-in. cyls., 26 in. stroke, by Robey & Company, Limited. Cross Compound Horizontal Condensing Engine, 11½ in. and 17½ in. cyls., 18 in. stroke, by Marshall, Sons & Company, Limited. Vertical Compound Open Type Engine, 12 in. and 19 in. cyls., 12 in. stroke, by Tangyes, Limited. Nearly New Surface Condensing Plant, by F. Pearn & Company, surface area of tubes about 1,200 ft., compound engine, etc. Ingersoll Sergeant Direct Line Steam Driven Air Compressor, 14¼ in. air cyl., 14 in. steam, 14 in. stroke, capacity 384 cub. ft. free air per minute. Vertical Three-Throw Geared and Belt-Driven Hydraulic Pump, by H. Berry & Company, 2½ in. rams, 6 in. stroke, working pressure 1,500 lbs. 4 ft. Arm Bickford Radial Drilling Machine, 3 in. balanced spindle, T slotted low base 4 ft. by 3 ft. Four 3 ft. 4 in. Cold Iron Band Sawing Machines, by Noble & Lund, two T slotted tables 3 ft. 9 in. by 1 ft. 9 in. Vertical Boring and Turning Mill, with 50-in. table, two tool boxes on cross slide, by the Bridgeport Machine Tool Works, Limited. Horizontal Boring Machine, by the Lucas Machine Tool Company, 3-in. spindle, T slotted table 3 ft. 6 in. by 1 ft. 10 in.

Catalogue of Stock Machinery, 6,000 Lots, Free on application. Inspection invited.

THOS. W. WARD, LTD.,
ALBION WORKS,
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COMPLETE New Portable Cutting Plant, £15 10s.; approval. Welding Plant, with six blowpipes, £22, including expert tuition at customer's works; approval. Cutting Blowpipes, unused, but soiled, £3; 1922 pattern.—STANSELL'S ACETYLENE COMPANY, LIMITED, Exeter.

NINE nearly new Steel Hopper Wagons, standard gauge, roller bearings.

Two sets of Belt-driven Geared Hydraulic Pumps, 2-in. rams and 4-in. rams.

Brand new 4-ft. under-driven Sand Mill.

10-kw. Steam-driven Lighting Set, 110 volts D.C.; bargains.

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ADVICE and Handbook Free.—KING'S PATENT AGENCY, LIMITED, Director, B. T. King, Reg. Patent Agent, 146a, Queen Victoria Street, E.C.4.

MISCELLANEOUS.

OLD Burnt Cast Iron Annealing Stands and Firebars, and Old Burnt W.I. and/or Steel Annealing Pots for sale, regular supplies. Best offers to.—Box 316, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, Adelphi, Strand, London, W.C.2.

Wire: "Hammond, Boxted, Slough." 'Phone: 287 Slough.

LIST OF LADLES AND SHANKS IN STOCK.

GEARED CRANE LADLES.

Approx. Capacity.	Dia. Top.	Dia. Bottom.	Depth.	PRICE.
5 tons..	44 in.	41 in.	40 in.	£42
3 tons..	37 in.	35 in.	32 in.	£36
30 cwt. (Evans)	28 in.	26 in.	30 in.	£30

UNGEARED CRANE LADLES.

1 ton (Evans) ..	27 in.	25 in.	26 in.	£20
10 cwt. (Evans)	23 in.	21 in.	21 in.	£12

HAND LADLES WITH SHANKS—ALL NEW.

(3) 4 cwt.	16 in.	14 in.	15 in.	£4 ea. (3 in stock)
(14) 2 cwt... ..	13 in.	10 in.	10 in.	£3 ea. (14 „)
(7) 1 cwt.	10 in.	8 in.	10½ in.	£2/10 ea. (7 „)

STEEL LADLES.

20 tons New Steel Ladle. 15 tons Secondhand Steel Ladle.
5 tons New Steel Ladle.

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FOUNDRY MACHINERY MERCHANT,

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Modern Foundry equipped for weights up to 10 or 12 tons. Keen prices. Best quality.

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